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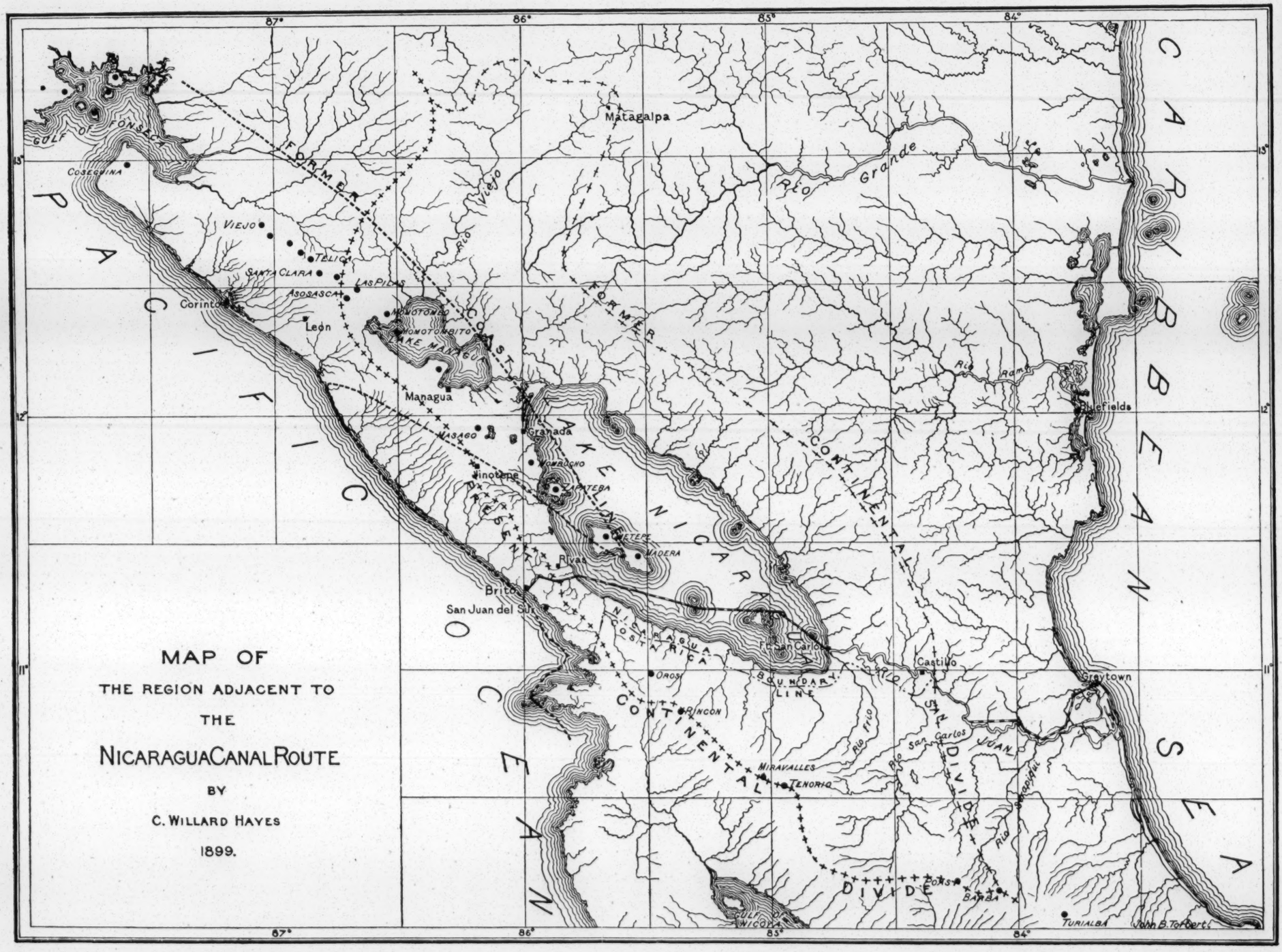

MAP OF
THE REGION ADJACENT TO
THE
NICARAGUA CANAL ROUTE
BY
C. WILLARD HAYES
1899.
PACIFIC OCEAN
CARIBBEAN SEA
NICARAGUA
COSTA RICA
GULF OF FONSECA
Matagalpa
Río Grande
Río Viejo
FORMER CONTINENTAL DIVIDE
PRESENT CONTINENTAL DIVIDE
SAN JUAN DIVIDE
BOUNDARY LINE
Río San Juan
Río Frio
Río Sarapiqui
Río Rama
Corinto
León
Managua
Granada
Masaya
Nindiri
Momotombo
Monotombito
Lake Managua
Viejo
Telica
Santa Clara
Las Pilas
Asosasca
Cosegüina
Nagarote
Matéare
Madera
Rivas
Brito
San Juan del Sur
Fuerte San Carlos
Castillo
Greytown
Bluefields
Oros
Rincon
Miravalles
Tenorio
Bagaces
Turialba
Gulf of Nicoya
John B. Tofbert C.
87°
86°
85°
84°
13°
12°
11°

THE
National Geographic Magazine

VOL. X JULY, 1899 No. 7

PHYSIOGRAPHY OF THE NICARAGUA CANAL ROUTE

By C. WILLARD HAYES,
United States Geological Survey

The region whose topography and geology have a most intimate bearing upon the problems connected with the proposed Nicaragua canal embraces northern Costa Rica and southern Nicaragua. It is sharply limited on the south by the high volcanic range of Costa Rica, which rears its massive form diagonally across the isthmus. It is limited to the north somewhat less definitely by the increasing height of a deeply dissected plateau, which merges with the mountains of northern Nicaragua. Between these limits lies a broad irregular depression, which extends very nearly across the isthmus in a diagonal direction parallel with the Costa Rican range. This depression is now occupied chiefly by Atlantic drainage, the continental divide lying within a short distance of the Pacific. It contains the basins of Lakes Nicaragua and Managua and their outlet, the San Juan river. It is important to note that the Nicaraguan depression is not a simple river valley. The portion with which we are chiefly concerned, that lying between the lake and the Caribbean, embraces two distinct drainage basins, whose streams formerly flowed in opposite directions, although by a geologically recent reversal of the drainage they now have a single outlet to the sea.

When examined in detail the surface of the Nicaraguan depression presents considerable relief, and its topographic features naturally group themselves into three classes.

Extending from the base of the Costa Rican volcanoes northward to the San Juan river and beyond are many hills whose

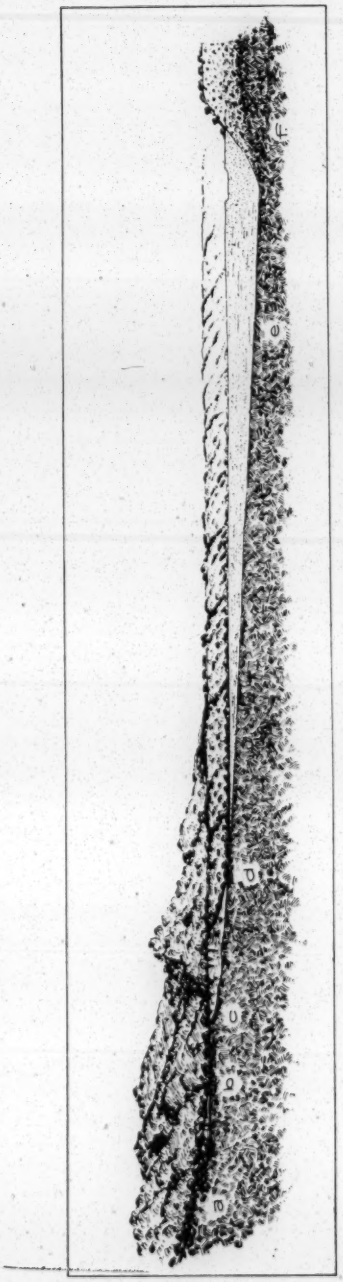
summits reach a tolerably uniform elevation on north and south lines, but increase in height from either side of the isthmus toward its axis. In the vicinity of the San Juan these hills have steep slopes and rounded summits. Some distance back from the San Juan the valleys which separate them are narrower, and there are considerable areas of level or undulating surface at an altitude corresponding with the summits of the hills nearer the center of the depression. It is evident that if the valleys were filled even with the summits of these hills, there would be formed a broad undulating plain, sloping gradually up from either side toward the axis of the isthmus. It is entirely probable that such a plain once existed, and that it has been converted into a series of even-topped hills and ridges by the subsequent cutting of stream channels below its surface. The manner in which this plain was originally formed is manifestly by the long-continued action of streams when the land stood considerably lower than now—that is, by the process of stream degradation or baseleveling. It was therefore a gradational, not a constructional, plain. If it were reconstructed by the filling of the stream valleys, its present altitude would vary between 100 and 200 feet.

As indicated above, numerous valleys now intersect the surface of this old plain. Except in the case of the San Juan they vary with the size of the stream which they carry. The reasons for this exception will be pointed out later. The valleys are broad in proportion to the extent to which the old plain has been destroyed, and they grow narrower with increasing distance from the axis of the depression. The smaller streams generally head in narrow gorges. In some cases they have not completely dissected the old plain, but flow upon its surface in shallow valleys which, lower down, give way to narrow gorges, and these in turn to the rather wide alluvial valleys near the trunk stream. The greater part of the erosion which has dissected the surface of the old plain was accomplished when the land stood somewhat higher than at present. The valleys were then much deeper and none had extensive floodplains, except perhaps the largest streams near the sea. The recent change in the altitude to the land has brought the valleys below sea-level, changing the rivers from corrading to aggrading streams. They have since silted up the estuaries which were thus formed, producing the wide alluvial plains through which they now meander.

Corresponding in some degree to the valleys incised within the old plain are eminences rising distinctly above its surface.

These are residual hills which, by reason of the harder rocks of which they are composed or their position on the divide away from the main drainage lines, were never reduced to the level of the plain. Where the plain was best developed, that is, near the sea margin on either side, these residual hills are infrequent and inconspicuous. To the southward of the San Juan, in the region lying between the Sarapiqui and the San Carlos, there is also an extensive area in which the hills are almost wholly remnants of the dissected plain, their summits in general presenting but little variation in altitude. To the northward of the San Juan the residual hills occur with increasing frequency and greater altitude, and finally merge with the mountains of northern Nicaragua. They also increase in number and height from either side of the isthmus toward its center, being most abundant along a line which crosses the San Juan valley in the vicinity of Castillo. If the old plain were reconstructed by the filling of the present valleys, it would not be continuous across the isthmus, but its eastern and western portions would be separated by an irregular line of these residual hills, the low gaps between them being slightly above the level of the plain.

The relations of these three classes of topographic forms will perhaps be made somewhat clearer by a reference to the accompanying idealized sketch and section on page 236. The surface of the peneplain is indicated by the even summits of the hills to the right. Residual hills are represented to the left, rising abruptly and distinctly above the surface of the peneplain. The profile shows a transverse section of the San Juan valley and a longitudinal section of the valley of a tributary stream. The latter is represented as rising in the residual hills to the left and flowing for some distance in the narrow gorge *a b*. From *b* to *c* the stream flows in a broad shallow valley at about the level of the peneplain. From *c* to *d* it is in a narrow gorge recently cut and still being actively deepened within the peneplain. It emerges from this gorge at *d* and thence to the margin of the main river valley at *e* it meanders through an alluvial plain continuous with the San Juan floodplain *e f*. The bottom of the valleys which the tributary and the trunk stream occupied before the recent depression of the region is represented in the profile by the solid line between the alluvium and the underlying rock. When these valleys were formed they were considerably above sea-level and the streams had a much more rapid fall than at present, but they are now somewhat below sea-level.



IDEALIZED DIAGRAM TO ILLUSTRATE THE DEVELOPMENT OF THE PRESENT TOPOGRAPHY IN PORTIONS OF THE SAN JUAN VALLEY

Summing up the foregoing statements very briefly, it appears that the surface of the Nicaraguan depression consists of a broadly undulating plain formed by the erosion of streams flowing to the Pacific and to the Atlantic from low gaps at the divide. Above this plain are residual hills, most abundant at the axis of the isthmus, where the continental divide was formerly located, but increasing in height along the axis toward the north, where they merge with the mountains of northern Nicaragua, and finally, there are many valleys which have been cut in the surface of the plain by the erosion of streams after the region had been elevated to a higher altitude. The lower portions of these valleys have subsequently been drowned and silted up with the formation of broad alluvial floodplains.

During most of the time in which these topographic features were being developed the Pacific coast had an outline very different from that which it has at present. Lakes Nicaragua and Managua then had no existence, and the region which they now occupy was in part the basins of streams flowing to the Pacific, in part open ocean, and in part a bay which then indented the Pacific coast and whose southern point was near the present island of Madera. The relations of the present and former coast lines are shown on the accompanying map, plate 6.

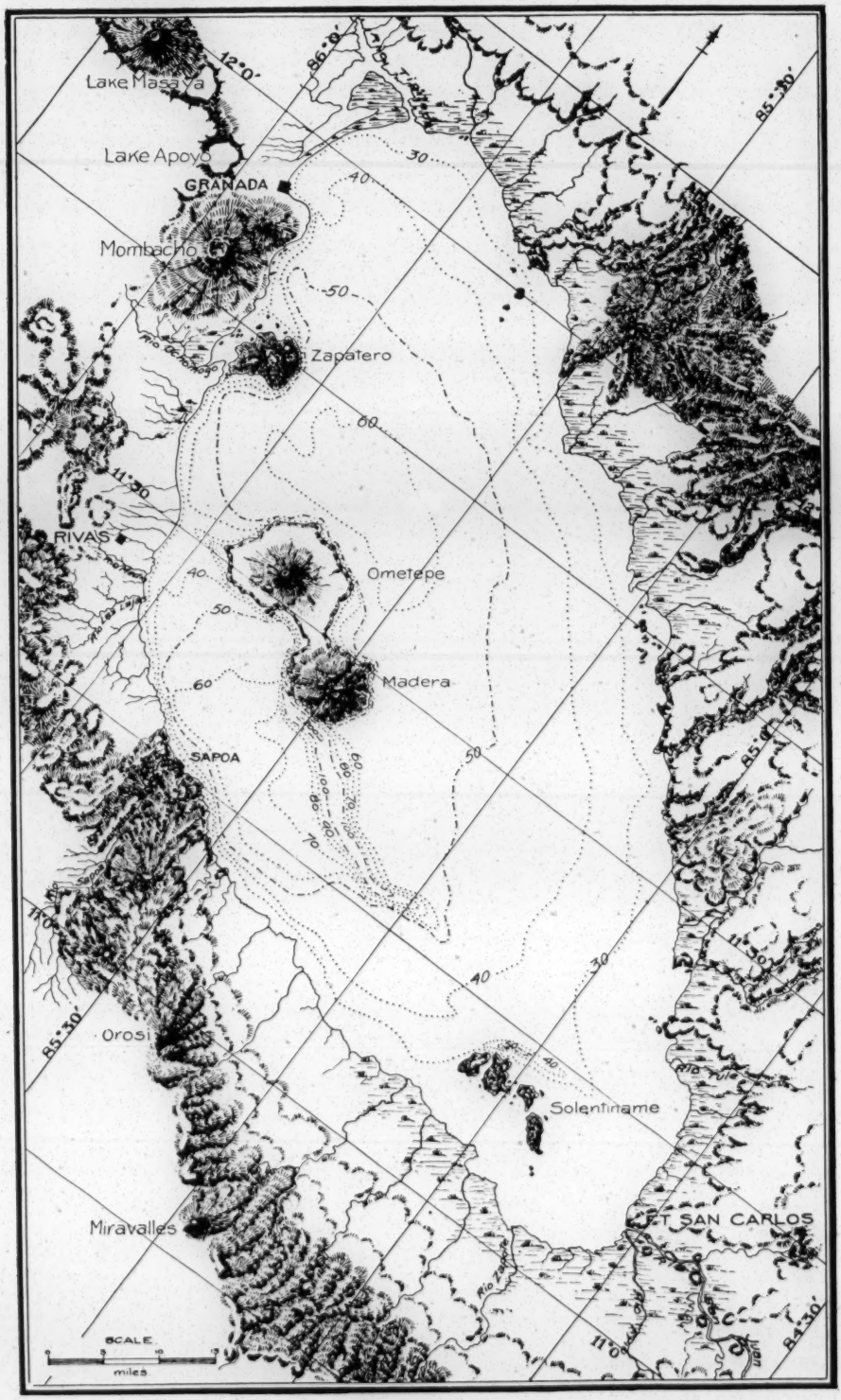
Lake Nicaragua has a regular oval outline, its longer axis extending about northwest-southeast. Its area is very nearly 3,000 square miles, and the mean elevation of its surface is about 104 feet above tide. Its shores present considerable diversity, depending chiefly on the character of the rocks which form them and the direction of the prevailing winds. The trade winds blow with great persistency throughout a large part of the year. They are deflected from their normal course by the high volcanic range of northern Costa Rica, so that instead of being northeast winds they vary from east to east-southeast. As a result of this constant wind direction the southeastern end and northeastern side of the lake rarely experience any surf, and hence those portions of the lake shore have no beach, but are bordered by swamps, with vegetation constantly encroaching upon the lake. Along the southwestern side and western end of the lake, on the other hand, there is a constant heavy surf and as a result a broad sand beach, generally backed by a wave-cut cliff. The accompanying map (page 239), based upon surveys made by the U. S. Nicaragua Canal Commission, shows the configuration of the lake basin. The most interesting feature shown is the old channel, evidently a drowned river channel formed when the southern half of the lake basin was dry land. This channel marks the course of a river formed by the union of the several streams now entering the lower end of the lake with the one which occupies the upper portion of the San Juan valley. It is first detected in the vicinity of the Solentiname islands, and if it was ever excavated between this point and the mouth of the Frio this portion has subsequently been filled by sediment brought into the lower end of the lake. From the Solentiname islands for about 10 miles northwestward there is only a slight indication of the channel. Thence to the base of Madera it is continuous and distinct. The greatest depth in the lake, over 200 feet, is near the western end of this channel.

To the west of the bay, which, as shown on the map, plate 6, formerly indented the Pacific coast, was a long cape or peninsula. This now forms a part of the narrow strip of land occupied by the continental divide between Lake Nicaragua and the Pacific. This part of the isthmus, although intimately connected with the Nicaraguan depression, is not properly a part of it. Its topography is particularly interesting in connection with the proposed canal, since it contains the lowest gap in the continental divide between the straits of Magellan and the Arctic ocean.

The manner in which this gap was developed is worthy of consideration.

Bordering the lake along its southwestern side is a very perfectly baseleveled plain from five to eight miles in width, which I have called the Rivas plain (see map, page 242). This is probably a portion of the same peneplain which forms the fundamental topographic feature of the Nicaraguan depression, and was at one time doubtless continuous with it. From the lake shore where the waves have cut a narrow terrace backed by a low cliff, the plain ascends toward the southwest at the rate of about 8 feet per mile. Its even surface is interrupted by occasional low residual knobs, which increase toward its inner margin, passing into the continuous ridges and high hills of the main continental divide. The Tola hills which border the Rivas plain on the southwest here extend to the Pacific, although further toward the northwest a narrow coastal plain is developed similar to the Rivas plain on the opposite side of the range.

The Tola hills doubtless correspond to the residual hills which rise above the peneplain of the Nicaraguan depression. They have a serrate outline, the altitude of their summits varying between 800 and 1,800 feet. While this range of hills still formed a long, narrow point of land between the *bay of Nicaragua* and the Pacific, the effect of deformations and wave erosion was such as to make the position of the divide unsymmetrical. As shown on the map, it was for a time located very much nearer to the Pacific than to the head of the bay. Hence the streams which headed upon the divide and flowed in opposite directions were of very unequal length. Those flowing east to the bay must have been five or six times longer than those flowing west to the ocean. Such conditions rendered the divide unstable and the familiar process of shifting toward a position of stable equilibrium took place. A stream occupying the position of the lower portion of the Rio Grande, by reason of the advantage which it possessed in having its fall concentrated within a short distance, cut back into the divide and diverted to its own basin successive portions of the opposing stream. At the beginning of the process an eastward-flowing stream occupied the valleys of the present Tola, upper Rio Grande, Guiscoyol, and lower Las Lajas. A small tributary headed against the Pacific stream on the divide in the vicinity of La Flor. This tributary was first reversed and then the upper portion of the original stream, the present Tola, was diverted toward the southwest. The same process was continued



MAP OF LAKE NICARAGUA

From surveys made by the U. S. Nicaragua Canal Commission, 1898-'99

until the divide was pushed back to its present position at Espinal. Streams to the northward also suffered some loss of territory. Thus upper tributaries of the Medio and Gonzales were diverted, forming portions of the present Guachipilin, Matinga, and Chacalapa. The deserted river valley formerly occupied by the eastward-flowing Tola and Cascabel, and from which the beheaded Guiscoyol now flows, forms the lowest gap in the continental divide. Its summit is 154 feet above sea-level, and the ascent is so gradual from either side that accurate instrumental work is required to locate the divide. During the wet season the gap is occupied by a swamp from which the water appears to flow both to the Atlantic and Pacific.

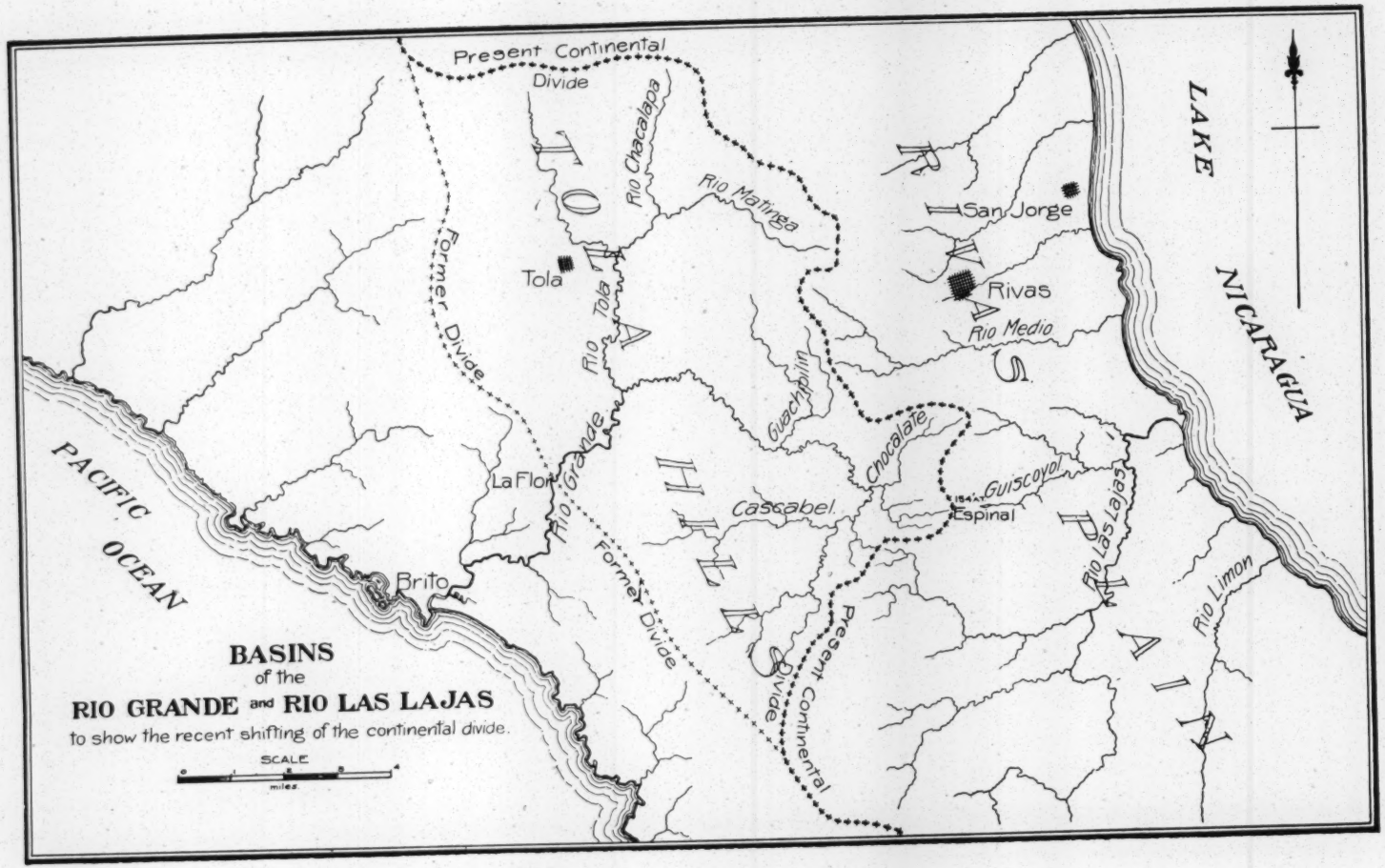
The map (plate 6), on which the present and former coast lines are represented, shows that a large land area has recently been added to this portion of the isthmus. The topography of this region differs totally from that of the Nicaraguan depression above described. The latter is an oldland, and its surface forms are those developed by the processes of subaërial degradation. The former, on the other hand, is composed of materials recently ejected from volcanic vents, and it retains to a large extent its original constructional forms.

Extending through the center of the area in question is a line of volcanoes, all of which are geologically very recent, while some are still active. From these numerous vents, which were at first submarine, a vast amount of material has been erupted, building up broad, gently sloping plateaus, from which rise more or less isolated volcanic cones. The southernmost of these volcanoes are the twin peaks of Madera and Ometepe, which occupy an island in Lake Nicaragua. Toward the northwest are Zapatero, also on an island, Mombacho, Masaya, Chiltepe, Momotombo, the clustered peaks forming the Maribios range, and finally Coseguina, on the Gulf of Fonseca. Most of these volcanoes have erupted both molten lavas and fragmental material, the latter varying from coarse blocks of solid lava to the finest dust. It is this fragmental material which gives to these volcanoes their beautifully symmetrical forms. Those which have been recently active, as Ometepe and Momotombo, are almost perfect cones. The effects of erosion, however, are seen almost before the volcanic activity ceases, and the symmetry of the cones is quickly destroyed. The details of outline in the ash cones vary from year to year. When the loose material has been removed or modified by erosion the summits assume the

irregularly rounded form seen in Madera and Zapatero. In some cases the conical summit is destroyed, not by the slower process of erosion, but by an explosive eruption. The result is an irregular, jagged truncation of the cone, usually with a depression in the center occupied by a lake. This form is seen in Mombacho and Coseguina. There is a tradition that the former was once a conical peak, and, as is well known, the summit of Coseguina was blown off by an explosive eruption in 1843, the most violent recorded eruption until surpassed by that of Krakatoa in 1883.

These volcanoes rise from a level plain which stretches from the head of Lake Nicaragua northwestward to the Gulf of Fonseca. It is composed wholly of fragmental volcanic materials, which reached their present position probably in the form of mud flows. The materials are not sorted, though successive layers are separated by distinct planes. In a quarry near Managua human tracks have been found in this material, showing that it is very recent, and also affording some indication of the physical conditions under which it was deposited. To the southwest of this plain and separated from it by a rather steep escarpment is a plateau which slopes somewhat gradually from an altitude of about 1,200 feet along its inner margin southwestward to the Pacific coast. This plateau is composed of exactly the same materials as the lower plain to the east, and it appears probable that the two surfaces were once continuous, but have recently been separated by a fault.

From all the evidence thus far obtained, it appears probable that during early Tertiary time the waters of the Atlantic and Pacific had free intercommunication across this portion of the isthmus. During that time sedimentary rocks were accumulated over a considerable portion of the isthmus and great masses of volcanic rocks were poured out upon them. In middle Tertiary time the region was elevated above sea-level, and there is no evidence that it has at any time since been depressed so as to give free communication between the two oceans. The elevation of the region was followed by a long period of erosion, during which its surface was reduced to a broadly undulating plain. The main divide was then near the axis of the isthmus, and from this divide streams flowed in opposite directions—eastward to the Caribbean and westward to the bay which indented the Pacific coast. After the surface of the country had been considerably reduced across this narrowest portion of the isthmus the region


Present Continental Divide
Former Divide
Rio Chacalapa
Rio Matinga
Tola
Rio Tola
Rio Grande
La Flor
Brito
PACIFIC OCEAN
Former Divide
Cascabel
Guachipilin
Chocalate
Guiscoyol
1844
Espinal
Rio Las Lajas
Present Continental Divide
San Jorge
Rivas
Rio Medio
LAKE NICARAGUA
Rio Limon
BASINS
of the
RIO GRANDE and RIO LAS LAJAS
to show the recent shifting of the continental divide.
SCALE
miles

suffered another elevation. The streams were thereby stimulated and began to trench the surface of the baseleveled valleys which they had previously formed. Shortly after this elevation there was a renewal of the volcanic activity, which had been quiescent for a long time. This second distinct period of activity has continued down to the present time. It was manifested along two nearly parallel lines of vents. One of these lines gave rise to the Costa Rican volcanic range, and the other to the Nicaraguan range. The vents forming the latter were submarine. They occupied a line nearly parallel with the Pacific coast, terminating to the southward near the southern end of the bay which then indented the Pacific coast. Vast quantities of lava and ashes were thrown out from these vents, and their position was such that the ejected materials formed a dam, cutting off the bay from the ocean. Since the precipitation was greater than the evaporation, the waters collected behind this barrier, and, as their surface was gradually raised, encroached upon the basins of the streams which had been tributary to the bay. The water doubtless continued to escape westward for a long time after the volcanic activity began, but successive eruptions finally raised the dam to such a height that the impounded waters found a gap in the continental divide, which was lower than the dam to the westward. They then escaped eastward to the Atlantic. The continental divide, which had previously occupied a position near the axis of the isthmus, was thus abruptly shifted to its present position near the Pacific coast west of the lakes. When the waters of the lake first overtopped the continental divide they were doubtless considerably higher than at present. The material forming the divide, however, was residual clay and deeply weathered rock, and the outlet was quickly lowered to the solid rock, where it has been held practically unchanged to the present time.

The latest episode in its geologic history has been the depression of this portion of the isthmus to the extent probably of one hundred or two hundred feet. By this depression the lower portions of the river valleys were drowned, forming long tidal estuaries. The streams flowing to the Pacific have in most cases entirely filled these estuaries with sediment. Thus the Rio Grande valley, which is followed by the western portion of the canal route, is a flat alluvial plain about a mile in width between the abrupt margins of the older valley. This plain extends out nearly even with the headlands, which are connected by a long curving beach.

A few of these Pacific streams have not yet completely filled their old valleys with sediment, and the unfilled portion of one now forms the harbor of San Juan del Sur. The San Juan river, flowing eastward to the Caribbean, has not only filled the estuary which once occupied its valley, but has pushed the coast line eastward by a broad delta plain.

The San Juan river and its valley bear such an intimate relation to any canal scheme that a somewhat more detailed account of its peculiarities should be given. Considered from any point of view, either with reference to the history of its development, the present character of its channel and banks, or the possibility of using it for a canal route, the San Juan valley is naturally divided into three sections. Starting from the point where the river leaves lake Nicaragua, the first extends to the head of the Toro rapids; the second from the head of the Toro rapids to the mouth of the San Carlos river, and the third from the mouth of the San Carlos to the sea.

In the upper section the river has a moderate current and a considerable depth. Its banks are low and swampy, except where it swings against the foot of one of the numerous hills rising above the alluvial plain through which it meanders. It is evident that the lake formerly extended down to and beyond this point, and that a large amount of territory has been reclaimed from its waters. It is well recognized that lakes are ephemeral features, and the ordinary ways in which they are obliterated are by the filling from their upper ends and by the cutting down of their outlets. In this case, however, the first of these processes has been exactly reversed. The area of the lake is being contracted chiefly by filling at its lower end. The filling is being accomplished not by the water which comes from the lake, since this is practically clear, but by the tributaries which entered this lower portion, many of which have been converted into tributaries of the San Juan. The present river channel does not coincide with the position of the river which formerly occupied this basin before it was drowned by the waters of the lake. Its position is dependent upon the relative amounts of sediment delivered by the tributaries on either side, and it has been pushed toward the northern edge of the old basin by the larger tributaries from the south—the Frio and Poco Sol. This may best be described as a *residual river channel;* that is, a broad arm of the lake has been gradually constricted by the deposition of sediment on its margin, and all that remains is the nar-

row river channel, kept open by the current of water flowing from the lake.

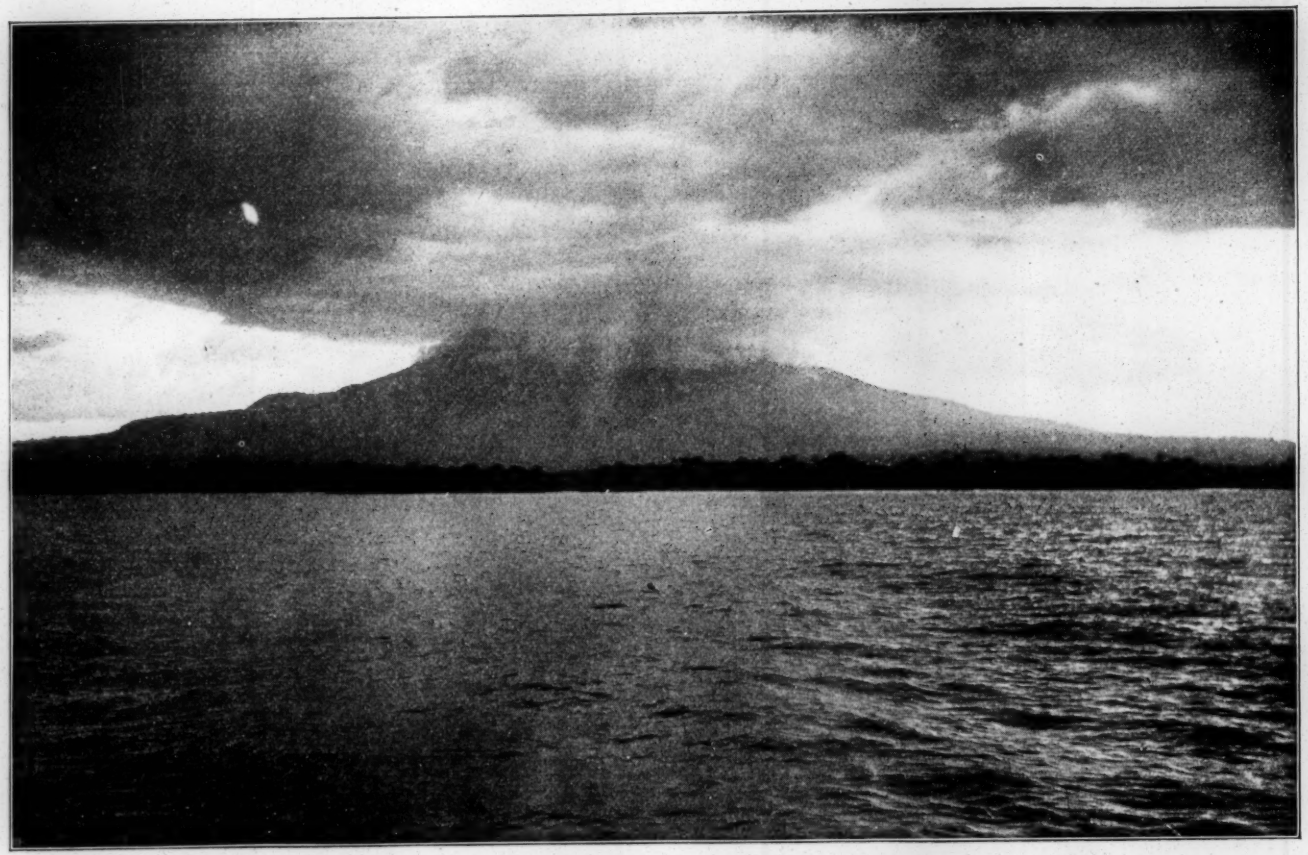
The second section of the San Juan extends from the head of the Toro rapids to the mouth of the San Carlos. Its essential characteristics are the rapid fall of the river and the narrow valley in which it flows. The Toro rapids which retain the lake at its present level are not formed by a solid ledge of rocks crossing the valley, but by boulders, sand, and clay. It appears that when this arm of the lake extended down to the continental divide it received a rather large and swift tributary, the Rio Sabalos, near its head. The sediment carried by the Sabalos, consisting of clay, sand, and boulders, was deposited on reaching the quiet water. A delta was thus formed extending as a shoal across the arm of the lake at this point. As the river channel sank in the gap across the divide the latter became lower than the surface of the Sabalos delta, and the crest of the barrier which maintains the level of Lake Nicaragua moved westward from its original position at the former divide to the present position of the Toro rapids.

From the head of the Toro rapids to Machuca the river channel consists of rather long, quiet reaches separated by rapids. The total fall in this section is about 40 feet, or an average of two feet to the mile. Of this fall, however, all but about six feet is accomplished by the numerous rapids. These appear to be due to the unequal hardness of the underlying rocks. The intervening quiet stretches are located upon softer rocks, which are worn down by the moderate current more rapidly than the harder rocks by the swift current of the rapids. Between Machuca and the mouth of the San Carlos the river is deep and narrow and the current is generally moderate. In some places at low stages of the river it is almost imperceptible, and when the San Carlos is in flood the current may even set upstream for a time. The water has a depth varying between 15 and 60 feet, the bottom of the channel being at some points below sea-level. It is evident that the present river is here flowing in a channel which was cut when the land stood higher than now, and which has not yet been filled by sediment. This portion is called the Agua Muertas, or dead water.

The third section of the river extends from the mouth of the San Carlos to the Caribbean sea. With the entrance of the San Carlos the character of the San Juan is entirely changed. Above the junction it is a comparatively clear stream, and except at the

rapids has only a moderate current. Below the entrance of the San Carlos it is usually muddy; it is shallow, with a shifting, sandy bed and has a uniformly strong current. Its slope is nearly a foot to the mile in this section. The Sarapiqui is similar to the San Carlos, although somewhat smaller. Both of these streams have their sources on the slopes of the Costa Rican mountains to the south. The recent volcanic eruptions of this region have furnished an abundant supply of unconsolidated sand to these streams and they are heavily loaded with this material. Below the entrance of the San Carlos the floodplain immediately adjacent to the San Juan has been built up more rapidly than the floodplains of its smaller tributaries; hence the latter are ponded in their upper courses and many lagoons are thus formed. From the mouth of the San Carlos eastward the San Juan occupies the northern margin of its valley. This is doubtless due to the more abundant supply of material furnished by the southern tributaries and also to the northward drift of the littoral current in the Caribbean sea. As the river extended its course eastward by the filling of the estuary, and later by the formation of the deltaplain, it was continually crowded to the northward by the direction of the sand-drift along the coast. This tendency became more pronounced the farther out the delta was built, and the sharp northward bend of the lower San Juan is its direct consequence.

As the river channel was carried northward this northern portion of the valley would be filled first and to a higher level than the southern portion. The river would thus at times find itself in a position of unstable equilibrium and would seek a new channel on the lower part of the deltaplain to the southward. Thus it is probable that the river originally occupied the present position of the San Juanillo. When this position became unstable it gradually deserted its northern channel for the present position of the lower San Juan. Subsequently the latter became unstable, and a more favorable course to the sea was found still farther south. The recent channel of the Colorado was then developed at the expense of the lower San Juan. This process is still going on, and the relative amounts of water carried by the two channels has very materially changed within a generation. Unless artificially modified, the lower San Juan will continue to dwindle, and probably all the water will find its way to the sea by the Colorado or by some more favorably located channel still farther south.



MOMBACHO IN CLOUDS

NICARAGUA AND THE ISTHMIAN ROUTES

By A. P. Davis,

Hydrographer, U. S. Geological Survey

The state of Nicaragua is the largest of the Central American republics. It lies entirely within the torrid zone, and contains about 49,000 square miles, or about one-fourth more than the state of Ohio, and is on the same meridian of longitude. It is bounded on the east by the Caribbean sea, on the west by the Pacific ocean, and lies between the republics of Honduras and Costa Rica to the north and south. The northern part is largely occupied by rugged mountains belonging to the main axis of the Cordillera. A little farther south this range divides into two main spurs, one following a southeasterly course, nearly parallel to the Caribbean coast, almost to the south boundary of Nicaragua, where it is cut through by the San Juan river. The west branch closely follows the Pacific ocean, and is peculiar in its low altitude and the narrow strip of land it occupies.

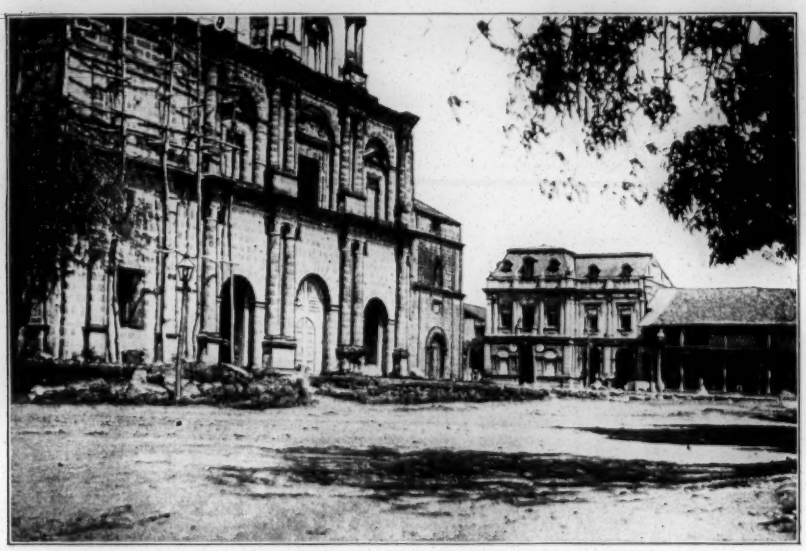
The east coast for a distance of 20 to 30 miles inland is mostly of a swampy nature. High rolling country approaches the coast at Monkey Point and near Greytown, but with these exceptions the coastal region is low, flat, and during the rainy season largely covered with water.

Reliable information regarding rainfall in Nicaragua is extremely meager. There is a record of 19 years at Rivas, which began in January, 1880, and is still continued. This record has been voluntarily kept by Dr Earl Flint, an American resident of Rivas. A rainfall record was kept at Masaya from July, 1886, to December, 1896, by Mr William Climie. The observations were then transferred to Granada and have been continued ever since, although results are at hand only to the end of 1897. Observations of rainfall were also made in Granada in 1876 by Ramon Espinola, and in 1877 by Dr Flint; also in 1883 and 1884 by the National Institute at Granada. At Bluefields observations were made by Hon. W. H. Jackson and others from September, 1883, throughout 1884 and 1885, and a portion of 1886. The Nicaragua Canal Company kept a record of rainfall at

Greytown for the years 1890, 1891, 1892, and a portion of 1893. The Nicaragua Canal Commission took observations at a number of points during the year 1898, in connection with other meteorologic and hydrographic measurements. An examination of the records and diagrams shows in a striking manner the fact that along the east coast there is no definite dry season. The maximum rainfall yet measured was that for the year 1890, when nearly 300 inches of rain fell at Greytown, and the year 1892 showed nearly as much. In the region of Lake Nicaragua and on the west coast there is a distinct dry season from about December 1 to the middle of May, when rain seldom falls, and never in large quantities. The total rainfall on the east coast is much greater than on the west, both from the absence of any dry season and from the heavier monthly rainfall, the mean so far observed at Rivas being under 70 inches, while that at Greytown is about 250. This fact is easily explained by the direction of the trade winds, which, blowing with remarkable persistency and uniformity from the Caribbean sea, are robbed of the greater part of their moisture in passing over the mountains east of Lake Nicaragua. The gap formed in these mountains by the San Juan, however, allows a portion of the moisture to be carried past, even during the dry season, so that at Fort San Carlos, where the San Juan river leaves Lake Nicaragua, rain is liable to fall any month in the year, though in quantities far less than on the Atlantic coast, while on the east and south shores of Lake Nicaragua, a few miles north or south of Fort San Carlos, no rain falls in the dry season.

Although Nicaragua is almost entirely covered with dense forest growth, the really useful timber is not abundant. A district on the Atlantic slope near Bluefields affords large quantities of yellow pine of fair quality, which, however, is not yet easily accessible. The only timber yet used to any extent for lumber is the cedar, which is soft, straight-grained, easily worked, and durable. The trees are scattered and not plentiful. The lumber is mostly sawed by hand. The timber of greatest value is the mahogany, which is cut for export to be used as an ornamental wood and in cabinet making. The monopoly of its export is conceded to an American firm. The wild cotton tree is sometimes used in making canoes. A number of the forest woods found in Nicaragua are heavy and so hard that it is impossible to drive nails or spikes into them, but they are exceedingly durable. A variety of dye-woods is found in various parts.

The present population of Nicaragua is estimated at about 400,000, or only about eight to the square mile. Of each hundred inhabitants there are 50 Indians, 1 negro, 45 of mixed blood, and 4 whites. They are sharply divided into classes, the Caballeros, or "*gentlemen*," and the peons, or laborers, who can be distinguished by their costume as far as they can be seen. This classification is punctiliously observed on all occasions, and is particularly noticeable on railroad trains and steamboats. The upper classes dress very much as we do in summer, that season being perpetual in Nicaragua. Among the lower classes the men's costume usually consists of a straw hat, a short cotton



PRESIDENT'S PALACE — CHURCH ON LEFT INJURED BY EARTHQUAKE

shirt, and trousers of darker material. No shoes are worn, but sometimes a pair of light sandals are used as a protection against hot or thorny ground. The dress of the women is even more scant, being minus the hat and sandals, a skirt substituted for the trousers, and the arms and upper part of the bust entirely bare.

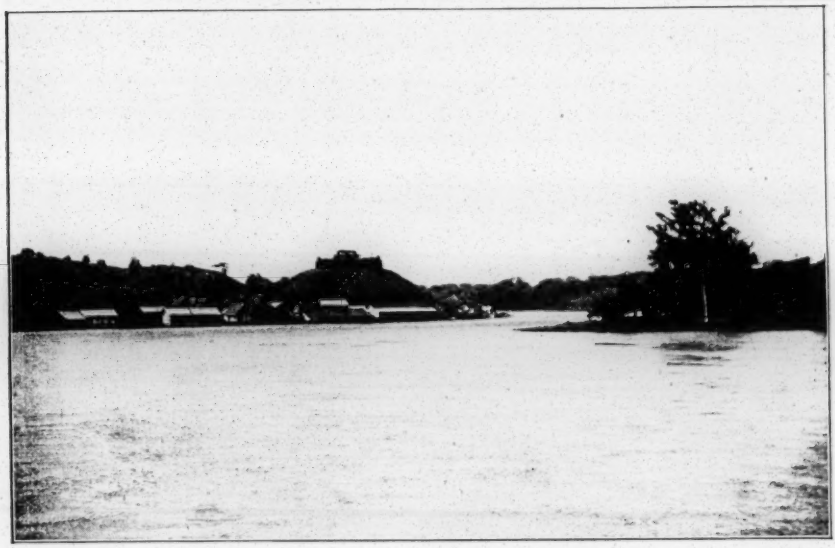
The country people and the poor of the cities live in thatched huts, with walls rudely constructed of upright poles, or with no walls at all. The better buildings in the cities are of stone, brick, or adobe, stuccoed with cement, and covered with tiles. They are cool and comfortable and almost fireproof, but sadly lacking in light. The president's palace in Managua has glass windows,

and a few Americans in Greytown enjoy the same luxury; but in Leon, Granada, Rivas, or any other city of Nicaragua there is hardly a pane of glass. By far the finest buildings are the churches and cathedrals. The sidewalks are often only three or four feet wide, and change their grade with nearly every house they pass, so it is necessary to climb up or down three or four steps every fifty feet or so. The streets are narrow and usually unpaved; but most of the towns are built on sandy or rocky ground, so that mud is not much encountered.

The peculiar interest attaching to Nicaragua from the American point of view is the promise held out by the remarkable hydrographic and topographic conditions of a practicable route for a large ship-canal.

These conditions consist of a large, deep lake 100 feet above sea-level, separated from the Pacific ocean by a narrow strip of land, containing the lowest depression in the continental divide between the Arctic ocean and the Straits of Magellan, and a large navigable stream carrying the surplus waters from the lake to the Caribbean sea. This route is especially fortunate in having at its summit level a magnificent natural reservoir in Lake Nicaragua, fed by an ample drainage basin. This reservoir is useful not only for storing water for operating the locks of the canal, but also for regulating the control of great floods that could hardly be provided for at practicable cost without its aid. No other route enjoys advantages of this kind.

The San Juan river is the sole outlet of Lake Nicaragua and its tributary drainage basin. Its total length from the lake to the sea is 124 miles, and it is usually navigable for light-draft river steamers. It leaves the lake at Fort San Carlos at an altitude varying from about 97 feet to about 111. Its course for a distance of 26 miles is through a low, swampy country, relieved by occasional hills. Through this course the river is sluggish and receives several tributaries of small discharge, which, in the dry season, are practically still water. The principal of these are the Melchora, Media Queso, Palo de Arco, and Rio Negro. The first tributary of importance to the San Juan river is the Rio Sabalos, which enters from the north and empties 26 miles east of Fort San Carlos. About half a mile below the mouth of the Sabalos are the first rapids, called Torro rapids. These rapids are caused by boulders and gravel, probably brought into the river by Rio Sabalos in former times, but do



CASTILLO RAPIDS — TOWN AND FORT

not seriously obstruct navigation except in times of extremely low water. Below this point the San Juan receives the waters of a few streams, the principal of which are the Rio Poco Sol and Rio Santa Cruz. Ten miles below Torro rapids are the largest rapids on the river, at Castillo Viejo. As the river here falls about five feet in a few hundred feet, steamers are seldom taken over except in high water. A railroad about 2,000 feet long is provided for the portage of freight and passengers on the right bank of the river.

Below Castillo are the Diamond, Balas, and Machuca rapids, the last-named being 13 miles from Castillo. All these rapids admit the passage of river steamers, except at extreme low water. Below Machuca there are no more rapids. The river is now deep and sluggish for a distance of about 17 miles, until it receives the waters and sediment of the Rio San Carlos. This river is the largest tributary of the San Juan, rising far to the southward, in the mountains of Costa Rica, and bearing such a volume of sediment that a delta has been built up at its mouth. From this point to the sea the San Juan is a shallow stream with sandy shifting bed; 25 miles farther down the Serapiqui empties into the San Juan from Costa Rica. Of the tributaries to the San Juan it is second in size to the San Carlos, and, like the latter, bears

large quantities of sediment in times of flood. Eight miles below the mouth of the Serapiqui the San Juan assumes decidedly the character of a deltaic stream, and sends out a small distributary known as the San Juanillo, which meanders through the swamps to the northward and, after receiving the drainage of the Deseado, reënters the San Juan four miles above its mouth. Six miles below the exit of the San Juanillo, or about 105 miles from Lake Nicaragua, the main stream of the San Juan separates into two large distributaries, the larger, called the Rio Colorado, flowing eastward directly to the Caribbean, and the smaller, or Lower San Juan, meandering to the northeast and finding its exit into the ocean at Greytown. Between the mouth of the Colorado and the Lower San Juan another distributary, called the Rio Tauro, finds its way from the Lower San Juan to the sea.

The principal obstructions to free navigation of light-draft river craft from Greytown to Fort San Carlos consist of the shoal character of the Lower San Juan, especially in times of low water, and of the rapids lying between Machuca and the mouth of the Sabalos. For purposes of a ship-canal the river also requires deepening below the mouth of the San Carlos and between the Sabalos and Fort San Carlos.

When the three little caravels of Christopher Columbus sailed from Palos, Spain, in 1492, it was with the object of reaching the south and east shores of Asia by a shorter and easier route than any yet known. This was the first systematic effort ever organized with this object, but it marked the beginning of a series of similar attempts which have increased in magnitude and frequency irregularly to the present day. For nearly half a century these efforts took the form of a search for a supposed strait through the American isthmus. When at last the numberless fruitless efforts convinced the world that such a strait did not exist, the dream was changed to one of a canal to be cut through the isthmus, and later it was proposed to construct a railway capable of transferring loaded vessels across.

The project of a ship railway was promoted by the state of Honduras with reference to a line across its own territory, connecting the harbors of Puerto Caballos on the Atlantic and La Union on the Pacific. This route was examined by the British-Honduras Interoceanic Railway Company, and is said to offer many attractions as a route for railway transit.

The ship-railway route that has received the most attention,

however, is that across the isthmus of Tehuantepec in Mexico. This route was first explored about 1520 and its advantages utilized by the Spaniards in the transportation of shipbuilding materials. It was later abandoned and almost forgotten, until, in 1771, an expedition was fitted out to examine and report upon the topography of the isthmus and the practicability of a canal by that route. This examination was very superficial, and it was reported that a tide-level canal was feasible. Another examination was made thirty years later, but without result. After the independence of Mexico was established an examination was made by General Juan Orbegozo, who reported the canal project as "problematical and gigantic."

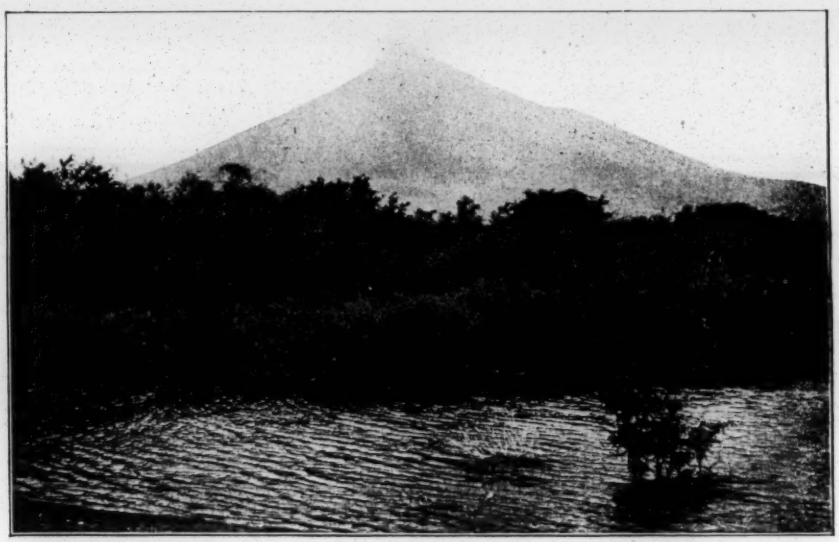
In 1842 Don José de Garay obtained from the Mexican government a charter for a canal or railway across the isthmus of Tehuantepec and appointed a commission to make a survey of the route. They reported the summit of the route to be 684 feet, and recommended the employment of the Chicapa and the Ostuta rivers as parts of a canal line. The length of the canal in excavation was to be about 50 miles, and 161 locks were to be constructed. A further examination and partial resurvey was made under the same concession, in 1851–'52, and more detailed information obtained.

Many years after this Capt. James B. Eads turned his attention to this route. After some investigation and discussion the project for a canal was abandoned on account of the large number of locks and great cost. Captain Eads adopted the idea of a ship railway over this route, and worked out elaborate plans, which have since been perfected and advocated by Mr Elmer L. Corthell, C. E. This project proposes 12 parallel rails, upon which is to run a huge carriage, supporting the entire ship and cargo as in a dry dock. Bends will be provided for when necessary by means of turn-tables. The motive power is to be two huge locomotives, which rest upon 6 rails. To provide for the passage of ships going in opposite directions and for repairs, turnouts are to be conveniently placed, the change of direction from the main track being effected by a turn-table.

The ship-railway project, however, has never succeeded in attaining the degree of popular approval that has been bestowed upon canal propositions. The general sentiment appears to be summed up in the epigrammatic expression, "A ship is never so well borne as when water-borne." The canal routes which have

attained the greatest degrees of public favor are the Atrato, San Blas, Panama, and Nicaragua.

Atrato Routes.—The gulf of Darien, an arm of the Caribbean sea, at the point where the isthmus joins the main continent of South America, receives the waters of the Rio Atrato, a navigable stream which rises and flows due north about 200 miles into the gulf. Its watershed is bounded on the west by the continental divide, which here hugs the Pacific coast very closely, and has several passes of moderate altitude. Various projects have been proposed to utilize this river and its tributaries to ap-



MOMOTOMBO

proach the Pacific coast as near as possible and then cut through the range to the sea. Of these projects the two that have received the most favor and attention are the two which utilize the Napipi and Truando rivers, tributaries of the Atrato. But neither has been regarded with as much favor as the more northerly routes.

The Napipi-Atrato route provides for making use of the Atrato river for a distance of about 140 miles and the construction of about 30 miles of canal, of which 3½ miles would be in tunnel. The estimated cost of this canal is about $98,000,000. The chief objections to this route are the long stretch of river navigation before the canal proper is reached, the uncertainty of tunnel construction and maintenance, the aggregation of a number of

locks close together near the Pacific coast, and the uncertainty of a sufficient water supply for the summit level.

The Truando-Atrato route is a modification of the Napipi-Atrato route, the project being to leave the Atrato river about 80 miles from its mouth and then to cut a sea-level canal through a tunnel under the continental divide into the Pacific, the flow of the Atrato river being diverted into the Pacific ocean. The length of the cut from the Atrato to the Pacific would be 43.2 miles. The cost of the work has been variously estimated from $135,000,000 to $156,000,000. The chief difficulties of this route are the considerable tunnel excavation and the control of the flood waters of the Atrato river.

San Blas Route.—This route lies between the gulf of San Blas in the Caribbean sea and the mouth of the Bayano river on the Pacific. It is the narrowest part of the entire isthmus, being only 30 miles from ocean to ocean. It is proposed that the level of the water in this canal be that of ordinary high tide in the Pacific ocean. The tides in the Caribbean sea being inconsiderable, no provision need be made to accommodate them; but on the Pacific coast the tides are from 16 to 20 feet, and a lock would have to be provided for maintaining the canal at any desired level. At high tide the lock can be left open, while at low tide there would be a considerable descent by means of the lock. This route requires the construction of a tunnel seven miles long, which it is proposed shall be 80 feet wide at the surface of the water and 140 feet high from the canal bottom. Much disagreement has arisen regarding the practicability and cost of the proposed tunnel. No work of any such magnitude or under such conditions has yet been attempted, and it is claimed that the gloom of a tunnel, the constant shower of chilled water from its roofs and sides, and its deoxygenated condition would rapidly undermine the health of the workmen, who would be unable to combat successfully the malaria and other enemies to health which abound on the isthmus. The long tunnel required, with the accompanying uncertainty of cost and practicability, is the chief objection to the San Blas route, though unquestionably this route has obtained a higher degree of public favor than any other excepting the Panama and Nicaragua routes.

Panama Route.—This route lies between Colon or Aspinwall, on the coast of the Caribbean, and Panama, on the bay of Panama. The existence of fairly good harbors at each end is one of the reasons for the advocacy of this route, and in 1851 a railroad was

built between these points to accommodate the sudden growth of travel between the eastern states and California, due to the gold excitement. The total length of this canal from ocean to ocean is 42 miles. Two distinct propositions have been advocated regarding this canal. The first, for a sea-level canal, was M. De Lesseps' scheme. The canal proposed by this project has a length of 45.5 miles, a depth of 28 feet, and a bottom width of 72 feet. It was estimated that 75,000,000 cubic meters of material would have to be moved, at an estimated cost of about $170,000,000. The only object in excavating a sea-level canal in preference to one with locks is to avoid the use of locks, but this cannot be avoided on the American isthmus, owing to the great range of tides in the Pacific. A sea-level canal, if constructed, would require the use of a lock on the Pacific side to control the tides, so that the advantage of such a canal is small when compared to the increased cost of construction which it involves. For many years this project was actively promoted in France and vast sums of money were subscribed for its construction. A large amount of work was actually done, the canal being practically complete for seven miles on its eastern end, and large quantities of heavy excavation made in the upper and

CALABRA CUT — PANAMA CANAL

western portions of the route. The work accomplished, however, represented only a small fraction of the funds subscribed, the balance being squandered in corruption and reckless extravagance. The scandals occasioned thereby led to the bankruptcy of the company and the suspension of the work. The sums actually subscribed and put into this work are variously stated as more or less than $260,000,000, not more than one-fifth of which is represented by actual construction.

On the reorganization of the company a balance of about twenty million dollars remained available for surveys and construction. The sea-level plan was abandoned, more complete surveys were made, and plans drawn up for a lock-canal, which is to be supplied with water from reservoirs to be constructed on the Chagres river. A small force is and has been for several years at work on construction, and the project is not by any means abandoned, though it is admitted that it will cost over $100,000,000 to complete the canal under any possible plan.

Nicaragua Route.—The advantages offered by this route for interoceanic communication were recognized at a very early period, and surveys were ordered by the crown of Spain as early as 1524, but were not executed. In later years several superficial examinations were made and many conflicting statements rendered, but all the really useful knowledge of this isthmus is of recent date. Nothing reliable and definite as to distances and elevations was obtained until 1850, when Col. O. W. Childs was sent there by the Atlantic and Pacific Ship-Canal Company. He made a reconnaissance of the entire strip of land between the Pacific and Lake Nicaragua, and made surveys of several routes to connect them. That from Salinas bay to Sapoa river he examined and condemned on account of the great elevation to be overcome. The favorite route of Louis Napoleon, by way of Lake Managua, he also condemned on account of its elevation and great length. His examination led him to the conclusion "that the line leading from the mouth of Las Lajas to the Pacific at Brito presented more favorable conditions for the construction of a canal than any other." The correctness of this conclusion is now universally acknowledged.

Colonel Childs estimated for the construction of a canal with a continuous depth of 17 feet. He proposed to hold the lake permanently at 108 feet above sea-level, and to overcome this elevation by 14 locks on each side, with a maximum lift of eight feet; the summit was to be controlled by dams at Castillo on

the east and Buen Retiro on the west. The total length of his proposed line was 194.4 miles, and the cost was estimated at $31,538,000. This included the cost of an artificial harbor at Brito; but at that time there was a good harbor at Greytown. The object of this survey was primarily to establish a means of communication with California to accommodate the heavy traffic induced by the discovery of gold.

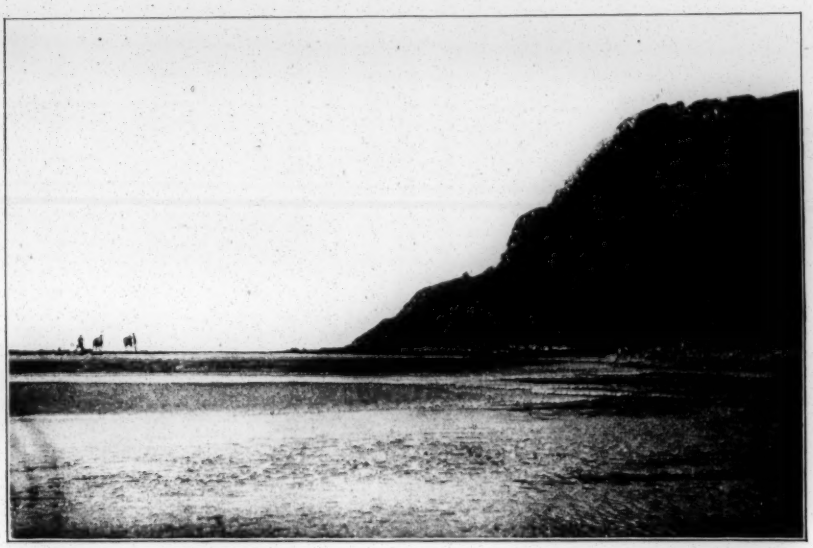
President Grant took a deep interest in the canal problem, and in 1872 appointed a commission consisting of General A. A. Humphreys, Chief of Engineers; C. P. Patterson, Superintendent of the Coast Survey, and Commodore Daniel Ammen, of the U. S. Navy, to examine the information at hand and determine the most feasible route for an interoceanic canal. The routes considered were the Tehuantepec, Nicaragua, Panama, and Atrato-Napipi. The commission unanimously reported in favor of Nicaragua, and this has ever since been regarded as the favorite canal route from the American point of view.

In 1873 an expedition was fitted out by the United States Government for the confirmation and continuation of the Childs survey. It was placed under the charge of Commander E. P. Lull, U. S. N., who surveyed the route with reference to the construction of a canal 26 feet deep. He confirmed the surveys of Colonel Childs, but fearing difficulty with the waters of the upper Rio Grande, he recommended that the canal leave Lake Nicaragua by way of the Medio instead of Las Lajas. This was shorter by a mile and a half, and avoided the Rio Grande, but involved a ninety feet deeper cut through the divide. The western half of the routes coincide, and reach the Pacific at Brito. Commander Lull also caused a reconnaissance to be made of a portion of Lake Nicaragua and of the San Juan river. It was thought that the river could be improved at the rapids by means of locks, and that by this means and by dredging, could be converted into a canal to a point near the mouth of Rio San Carlos. Here it was proposed to construct a dam, and the canal was to leave the river and follow near it until the swamp region was reached below the Serapiqui, and then to cut across to Greytown. Eleven locks were proposed west of Lake Nicaragua, and ten on the east side. The estimate included $2,500,000 for the restoration of Greytown harbor, and was in all $65,700,000.

Associated with Commander Lull in this survey was Mr A. G. Menocal, a civil engineer of the navy, who has since become famous as the chief engineer of the Maritime Canal Company,

STREET IN PANAMA

and to whom is largely due the public interest in the Nicaragua canal. In 1885 Mr Menocal was sent by the Government to continue the examination, and the plans adopted by Lull were completely revolutionized. On the west side he adopted the Childs route—by way of Las Lajas—the Rio Grande to be diverted from its course and turned eastward into Lake Nicaragua. The summit level of Lake Nicaragua was to be maintained at 110 feet by a dam across the San Juan at Ochoa, three miles below the mouth of Rio San Carlos, where the sailing line was to



MOUTH OF RIO GRANDE: PROPOSED SITE OF BRITO HARBOR

leave the river and follow nearly a straight line to Greytown, the summit level being maintained until the east divide had been passed, and the descent to the Caribbean made by three locks with a maximum lift of 40 feet. This necessitated the construction of a series of high embankments between Ochoa and the east divide, a distance of 12¼ miles. About half of this distance consists of steep clay hills, which were to be connected by the embankments, 67 in all, ranging from 6,000 feet long downward. The cut through the east divide was to be over three miles long and to have a maximum depth of 324 feet. This project was the one adopted with some modifications by the Maritime Canal Company. Two short basins were added by

the construction of dams on the Deseado and the Rio Grande up to the summit level. All these plans were elaborated in great detail, and the total cost was estimated at $65,084,176.

In 1895 Congress provided for a board of engineers to ascertain the feasibility, permanence, and cost of the canal, and appropriated the sum of $20,000 for the purpose. Col. William Ludlow, of the army, Civil Engineer M. T. Endicott, of the navy, and Mr Alfred Noble were appointed by President Cleveland to constitute it. Considering the time and funds at their disposal, this board made a very thorough examination of the route, the data, and the estimates, all of which were freely discussed and criticised. They reported that while the canal was undoubtedly feasible, the information collected was entirely inadequate for a basis on which to make final estimates of cost or even to determine the practicability of certain peculiar features involved in the company's plan. They recommended, therefore, that an appropriation of $350,000 be made for further surveys and investigation. A provisional estimate made the cost just about double that estimated by the company. Accordingly, a commission was appointed by President McKinley, consisting of Rear Admiral J. G. Walker, Col. P. C. Hains, and Lewis M. Haupt, for the further survey and examination of the canal route.

The points of weakness in the company's data were numerous and some of them serious. The borings on some parts of the line were meager, and in many cases the results had been confused and the cores taken had been lost. The Ochoa dam was to be constructed of large rocks loosely dumped into the stream and left to find their own foundation. This style of dam involved the use of rocks of very large size and of hard and permanent structure. The intention was to obtain this material from the deep cut through the east divide. Investigation, however, aroused serious doubt as to the existence of a sufficient quantity of hard, permanent rock in the divide for this purpose. No satisfactory information existed as to the foundations for the Ochoa dam and the San Francisco embankments. The large amount of material to be dredged in the San Juan river had not been investigated at all. But little was known regarding the foundations of the proposed dam at La Flor and the material to be dredged at Brito.

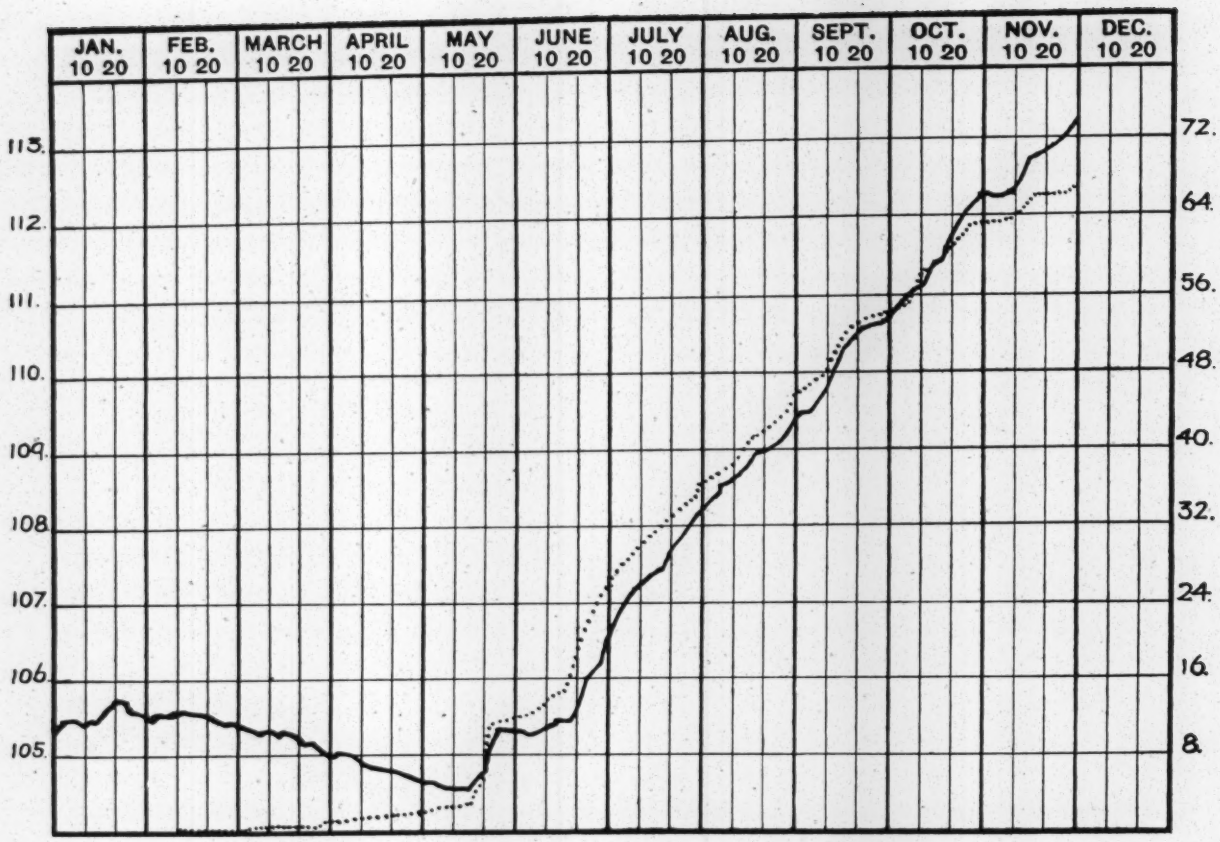
The greatest lack of information, however, was with reference to the hydrography. Though it was proposed to deal with the

floods of the San Juan, San Carlos, San Francisco, and other streams, no attempt had ever been made to measure their flood discharge or even to make an approximate estimate on this point. It was designed to hold the lake at an elevation of 110 feet above sea-level, any rise above that mark being injurious to property and any fall below reducing the navigable depth of the canal throughout the summit level; yet no attempt whatever had been made to determine the maximum or minimum inflow or the rate of outflow or evaporation from the lake. There was also some discrepancy in the levels and in distances on San Juan river and Lake Nicaragua.

The Walker commission directed its efforts to supplying these deficiencies and to the investigation of alternate routes with reference to comparative permanence, utility, and cost, and also to checking the results of surveys already made. Sufficient information has been obtained to fix plans and quantities within narrow limits, so that disagreements as to cost relate almost entirely to the relative efficiency of labor in a warm, wet climate as compared with temperate regions, where we have more data.

The hydrographic investigations included the measurement of all the principal streams encountered by the possible canal routes, the rainfall all along the line, the evaporation from Lake Nicaragua, and the sediment carried by the San Carlos and Serapiqui rivers with reference to its influence on the maintenance of the canal. The twelve camps which were established measured twenty streams and took the other observations required.

On the San Juan one station was maintained at Ochoa, where it is proposed to build the big dam. Another, just above Sabalos, was maintained as being the highest point on the river where a dam might be built and as giving essentially the outflow from the lake, there being no important tributaries between this point and the lake. During the latter part of the dry season a tour around the margin of Lake Nicaragua was made to determine the inflow during the dry season, and, though the preceding rainy season had been the wettest on record, the inflow was found to be practically negligible. Observations show that the average evaporation here in the dry season is about two-tenths of an inch per day. The length of the dry season and the rate of evaporation indicate that in ordinary years the surface of the lake would decline about two feet during the dry season, and this will, of course, decrease the navigable depth of the canal by



MEAN INFLOW TO LAKE NICARAGUA COMPARED WITH THE MEAN RAINFALL IN ITS BASIN

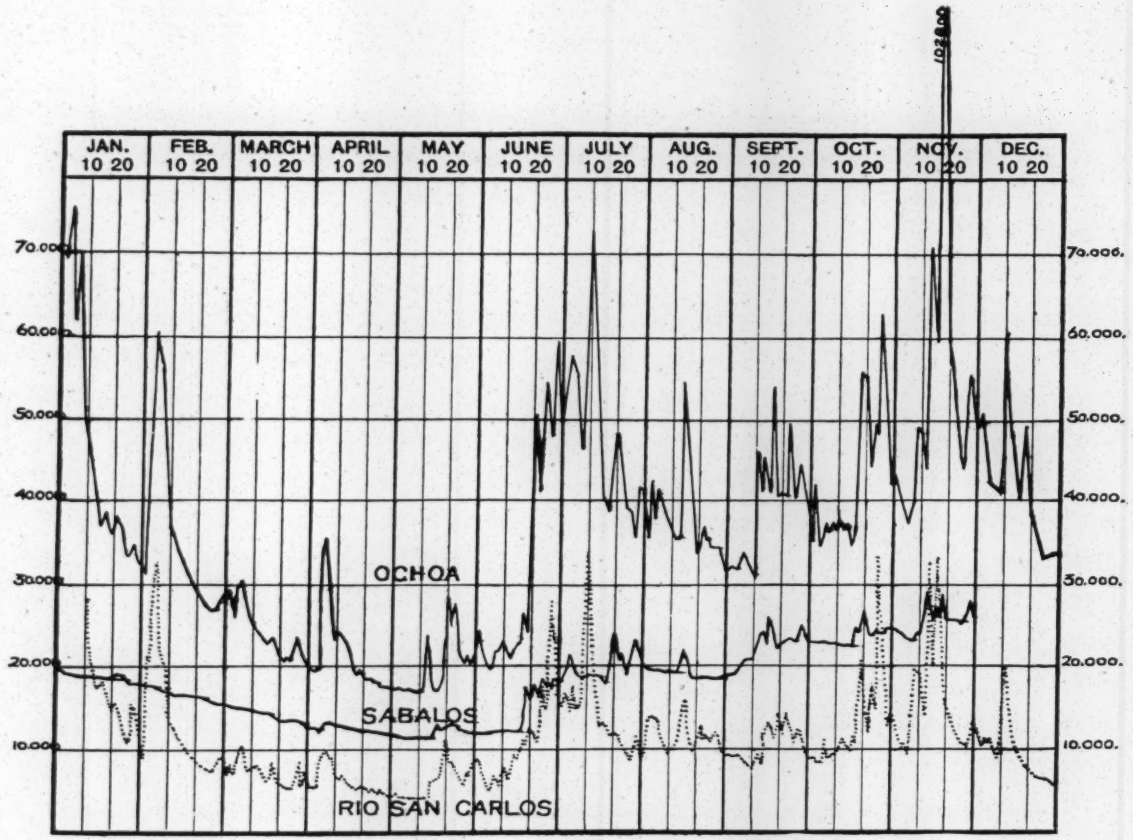


DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE RIO SAN JUAN ABOVE MOUTH OF SABALOS AND AT OCHOA, ALSO OF THE SAN CARLOS THREE MILES ABOVE ITS MOUTH, 1898

that amount throughout the summit level. Hence to maintain a depth of 30 feet it will be necessary to secure and hold a depth of 32 feet at the beginning of every dry season. There are very strong indications, however, that whole years sometimes occur in which the evaporation exceeds the rainfall by two feet, so that amount should be stored against the exceptionally dry years, and a depth of 34 feet secured at the opening of each dry season to secure a permanent depth of 30.

Only two streams carried any considerable quantity of water into the lake last April. These were Rio Frio, which empties at Fort San Carlos, and Rio Zapote, coming in at the extreme south end. A few springs and brooks also flow the year round, but most of the tributaries are, during the dry season, stagnant estuaries, from 10 to 25 feet deep. Aquatic vegetation grows in great profusion in these streams, choking the channel, unless a passage for navigation is kept open by canoes. This vegetation is not rooted to the soil, but floats freely and shows no disposition to flow out toward the lake. The water is dark-colored, foul, and stagnant. When the rainy season sets in in earnest, however, these wide, deep channels are filled with a rushing current so swift that it is very difficult to paddle a canoe against it. The floating vegetation is carried out in great quantities, forming floating islands several hundred feet across. As the current of the stream often extends far out into the lake, the floating vegetation forms a large crescent around the mouth, and in some cases constitutes quite an annoyance to navigation. Some of these islands find their way to Fort San Carlos, and pass down the San Juan river. The inflow to the lake is sometimes as great as 300,000 cubic feet per second, and to prevent injurious submergence of adjoining property it is necessary to provide a spillway of large capacity, and to control the discharge so as to waste the surplus and yet to store the large amount of water necessary to provide for the evaporation from this immense lake surface.

As illustrating the problems solved by this survey, the extreme flood discharge of Rio San Juan at Ochoa was estimated by the company at 63,000 cubic feet per second. A discharge of about 105,000 cubic feet per second has been already observed, and a study of the floodplain in connection with the observations at the same point shows that the maximum discharge cannot be less than 200,000 cubic feet per second, or more than three times the estimated maximum. The San Carlos and Serapiqui rivers

have been shown to carry such quantities of sediment, sand, and gravel that practically all plans for canalizing the river below the mouth of Rio San Carlos are prohibited. The section of the river between San Carlos and Sabalos, which requires such a large amount of dredging, has been shown by the borings to contain no solid rock, and these results have been confirmed most signally by Dr Hayes' development of the geological history of this river. A line of precise levels has been run from tide water on each side to the lake, thus settling all uncertainties of elevation. A careful survey was also made of Lake Nicaragua, locating the shoreline and fixing its depth at all points.

The route that now seems to be the best is in general similar to the one selected by Commander Lull in 1873.

It is now definitely settled, as stated by the commission, that the Nicaragua canal is a practicable proposition, all the serious difficulties being either eliminated or a method of solution pointed out. The cost, with a depth of 30 feet or more throughout, with locks large enough to receive the largest war vessels afloat, safe harbors at each end, and all constructions of the safest and most permanent character, will probably be about $125,000,000. Whether or not it will be worth that amount to the American people is another question.

SCENE IN RIVAS — READY TO START

THE WELLMAN POLAR EXPEDITION

With the news that arrangements have been made for the return of Mr Wellman and his party, speculations arise as to the probability of his having reached a point further north than has been yet attained. Up to the last word received all his plans had been carried out, and unless the unexpected has happened, there is reason to believe that success will be his reward. The story of the equipping and starting of the expedition has been told by Mr Wellman (*Century Magazine*, Feb., 1899)—told modestly and absolutely free from the exaggeration that such enthusiasm as his might well prompt. It was my good fortune to assist in the final preparations for the trip, and from an experience of travel under all sorts of conditions I could form an opinion as to how well he was prepared to meet any conceivable emergency. He had profited by the trials of all who had gone before, and had devised a number of expedients that gave promise of making his task easier. Unless the problem contains unheard-of factors, I feel sure that he will reach the ultimate north.

He sailed unusually early from Tromsö, intending to take advantage of any breaking up of the ice; but unfortunately the prevailing winds banked the ice up instead of driving it southward, so he was compelled to put back to Norway for coal and then make a second attempt. This time he pushed through to Franz Josef Land, and established his first camp on Hall island. The plan was to send northward a reconnaissance party to locate a favorable site for winter headquarters, and spend the remaining days of summer hunting, to lay in supplies for the men and dogs. The rest of the party would follow by slower marches, and bring up the heavier equipment for the winter and for the flying column that would start as early as possible this spring.

The strongest feature of Mr Wellman's plan is the way in which this advance is to be made. For this he secured devices that give the minimum of waste in motive power and material. He has sought to avoid the discouraging retraveling of the route by taking plenty of dogs and having light loads. One of the best proofs of the wisdom with which every detail has been looked after was the readiness of experienced men to accompany him. Of the five Norwegians in the party three have repeatedly en-

dured all the vicissitudes of Arctic work. After having assisted in the final preparations and seen each thread upon which their lives may depend, they embarked as though the goal were plainly in sight.

The past winter was to be spent in such rude huts of snow and walrus skin as they could erect. When the weather permitted they would train the dogs and practise on their *skis*, so that when the final start was made no time would be lost in breaking-in their forces. It was the intention to start from this winter camp as soon as the twilight was bright enough for them to see, and move northward to the Pole, returning in season to reach Franz Josef Land by the time the relief ship arrived there. They have sufficient supplies for another winter, and in case there should be failure this year in any part of the scheme they will remain until next summer. Every one is asking, "Will they succeed?" They will if they reached a high latitude last fall; if sickness did not weaken their forces during the long winter night; if the unprepared-for was not met. But each *if* must be written large.

J. Howard Gore.

THE COAST AND GEODETIC SURVEY: ITS PRESENT WORK

The wide scope embraced in the operations of the Coast and Geodetic Survey demands correspondingly wide limits in the character of the work and in the geographical distribution of its activity. Parties are now engaged on the Atlantic, Pacific, and Alaskan coasts, and in Puerto Rico. The coming season will witness great additions to our very incomplete knowledge of the mouth of the Yukon and of its approaches. The southern shore of Puerto Rico, contrary to the general belief, contains one or more good harbors, and the hydrography necessary to develop their commercial capabilities is now being rapidly executed. The great arc measurement on the 98th meridian is being pushed vigorously. This work is the worthy counterpart of the transcontinental arc on the 39th parallel, and will eventually become the backbone of the Mississippi Valley triangulation. The present year marks a notable era in Coast and Geodetic Survey work bearing on the figure of the earth, inasmuch as it will witness the publication of the definitive results of one of these arcs and the comprehensive prosecution of work on the other. This

season is the first in which several classes of work are carried on simultaneously and systematically on the 98th meridian.

A Coast Pilot party has been organized for the purpose of keeping the present publication up to date by additions and corrections. The information sought will be in the following lines:

I. General description of the coast line.
II. Detailed directions for avoiding dangers and obstructions.
III. General sailing directions.
IV. Geographical positions of lighthouses and beacons.
V. Practical information in regard to fog signals, tides, variations of the compass, etc.
VI. Views of the coast and principal harbors.

Additional work has been planned by the Coast and Geodetic Survey, but the parties have neither been assigned nor selected. A line of precise levels is proposed from the Great Lakes southward, crossing and checking our work on the 39th parallel, and continuing to Tennessee, there touching the lines from the seaboard by the Geological Survey, thence onward to the work of the U. S. Engineers in Mississippi, and finally connecting with our own levels brought north from the Gulf. Such a line would form a connecting link between the determinations of the three great government organizations.

E. D. Preston.

EXPLORATIONS IN ALASKA

During the past winter the members of the exploring parties that visited Alaska last year have carefully canvassed geographic knowledge of that country with special reference to determining in what localities exploration might be most advantageously carried on this summer. The large unexplored area lying south of the Yukon and west of the Alaskan mountain range, about the headwaters of the Kuskokwim and including the towering peaks of Mt McKinley and its neighbors, is a district of special interest toward which future exploration may probably be directed. But careful study has shown that, because of its inaccessibility except by river, no adequate returns could be expected from an expedition to that region this year. The experience of last season, when the exploring party could advance against the current of the stream but from one to three miles a day, and hence consumed all the time in getting there, has proved that the streams must be ascended while they are still

frozen; but to do this the expedition would have to leave Washington, D. C., in February.

Another district carefully considered in the preparation of plans is the general region of northwestern Alaska tributary to Kotzebue sound. It is well known that many prospectors have penetrated into the interior from the eastern shore of Bering sea, and that geologic investigation would probably reveal the western extension of the Alaskan gold belt. But all information available as to modes of travel and native routes prove to be of so vague a character as to render it advisable to obtain more definite information through exploration this summer before planning for the development of that region.

Still other plans were proposed and considered, but the final selection determined that two parties should be sent out by the U. S. Geological Survey, one into the region north of the St Elias range, and to proceed westward between the Tanana and Yukon rivers; the other to the headwaters of the Koyukuk river, within the Arctic circle. The object of both of these expeditions is the exploration of little known areas for the purpose of adding to geographic knowledge, but they differ in the scope of the work proposed, as our present knowledge of the two districts is very unequal.

The first mentioned party under Mr W. T. Peters, topographer, accompanied by Mr Alfred H. Brooks, geologist, provided with a pack-train of horses, will cross Chilkoot pass and pursue the Dalton trail for some distance. At a convenient point they will diverge to the west along the northern flanks of the St Elias range. It is expected that in their westward route they will determine the northern limits of ancient and modern glaciation from the range; that they will ascertain the position of the headwaters of the White and Tanana and Copper rivers and bring out a fairly accurate recognizance map of this unknown region. On striking the divide between the Tanana and White rivers, at the point where these same explorers last year crossed from one to the other, they will proceed northwestward into a comparatively well-known area, lying between the Tanana and Yukon. In this locality gold-bearing rocks are extensively developed and have been generally prospected. Maps of the area are, however, lacking, and it is the purpose of this expedition to prepare as thorough a map as the limits of the season will permit. Throughout the route careful geologic as well as topographic observations will be made, and it is expected that our knowledge of Alaskan geology will be greatly extended.

The second party, in charge of Mr F. C. Schrader, geologist, and Mr T. G. Gerdine, topographer, will proceed by the now well established route down the Yukon to Fort Yukon, or some point in that vicinity whence a convenient route northward can be found. The equipment will be the same as that used last summer, consisting of canoes and outfit that can be easily packed and carried. Beyond this starting point the route is left to the discretion of the chief of the party, but his general instructions are to penetrate the basin of the upper Koyukuk as far as possible. The main purpose of this expedition is necessarily geographic, but geologic information will be gathered so far as practicable. It is expected that valuable information will be gathered to determine future plans for the exploration of the region between Bering sea and Arctic ocean. This party will continue its work until forced to retreat before the advent of winter, and will then float down on the swift current of the Koyukuk river. Neither party will winter in Alaska. Although the advantages of such a course have been recognized, careful consideration shows that it is not expedient with present knowledge and available means.

METEOROLOGY IN THE PHILIPPINES

In view of a public presentation and criticism, through the medium of a printed circular issued by the director of the Manila Central observatory, of action taken by the United States government in suspending all telegraphic typhoon warnings made by the Manila observatory for points outside of the Philippines, it seems proper to present for the information of all persons and interests concerned a statement of the facts and circumstances which led up to the action taken by the United States authorities.

In a communication dated November 5, 1898, Dr W. Doberck, Director of the Hongkong observatory, informed the Chief of the United States Weather Bureau that the Manila observatory was continually communicating sensational typhoon warnings to the newspapers in Hongkong, and that as this action was against international regulations laid down for the guidance of meteorological authorities, which prohibit an authority in one country to issue storm warnings for another country, he desired and recommended that the American government of the Philippines put a stop to this irregularity, which interfered so materially with the work of the Hongkong observatory.

Acting upon the recommendation made by Dr Doberck, and approved by the Chief of the United States Weather Bureau, the Secretary of Agriculture requested the Secretary of War to provide for discontinuing telegraphic typhoon warnings from the Manila observatory to points outside of the Philippine islands. The position taken by the United States authorities was that the Manila observatory was improperly interfering with the British observatory by sending warnings into the territory covered by the observatory at Hongkong, and that warnings of this character should not be sent except upon the request of the British government. They held that as Director of the British meteorological observatory, having supervision over meteorological matters for the British government in China, Dr Doberck would not be justified in sending weather forecasts to Manila, and that such action on his part would, with propriety, be resented by the officials of the Manila observatory. In this position they were strengthened by the relations which have for many years existed between the prominent meteorological services of the world. The United States and Canadian meteorological services never presume to issue forecasts or storm warnings for any part of the territory under the sovereignty of the other, notwithstanding that they have in their possession daily meteorological observations from observatories both in the United States and Canada.

The British government has a chief observatory at Hongkong and possesses a chain of meteorological observatories extending 1,500 miles northeastward and 800 to 1,000 miles southward, and in addition receives reports from Bolinao, on the island of Luzon. In fact, the director at Hongkong possesses a system of observations which is necessary to the issue of forecasts that are worthy the serious attention of mariners. The habit of the Manila observatory of issuing storm warnings for Hongkong and the China coast was not only contrary to international usage, but was not justified by the possession of superior facilities for making the forecasts. The relative accuracy or value of the warnings issued by the Hongkong and Manila observatories and the comparative scientific attainments of the directors of these observatories had, under the conditions presented, no bearing upon the subject. Dr Doberck has by years of well-directed work and study established an excellent service and gained an enviable standing as a meteorologist, and is unquestionably entitled to the consideration and courtesy which usage has accorded to directors of meteorological services.

THE MISSION OF THE "DIANA"

The Peary Arctic Club, under whose patronage Civil Engineer Peary, U. S. N., is now engaged in an expedition to the North Pole, will dispatch the steamship *Diana* about the middle of July on the second of a series of annual reinforcements proposed by Mr Peary in his original plan of action. The *Diana*, a 427-ton steam barkentine-rigged sealer, built in Greenock in 1871, and thoroughly rebuilt, reëngined, and reclassed in Dundee in 1891, was engaged by the Canadian government during 1897 in the exploration of the water route for commercial purposes between Hudson bay and Liverpool. She is a fast, stanch, and commodious vessel, and the best which has yet been employed in the northern work.

The *Diana* is to be commanded by Capt. Samuel W. Bartlett, of Brigus, Newfoundland, and will be manned by a select crew of Newfoundlanders, familiar with the conditions prevailing in high latitudes. Captain Bartlett is a brother of Capt. John Bartlett, of the *Windward*, and of the late Capt. Harry Bartlett, of the *Falcon*, who were engaged in Peary expeditions. The former has not returned from the expedition of last summer, and the latter was lost with his ship and all on board while returning from Philadelphia to St Johns in the fall of 1894. The *Diana* will carry a scientific party headed by Prof. William Libbey, of Princeton University, for biological and oceanographic work, and a hunting party of four, led by Mr Russell W. Porter, of Boston. Robert Stein, of the U. S. Geological Survey, of Washington, with two companions, will also sail on the *Diana*, to be landed, if practicable, on Ellesmere land, where he expects to remain for one or two years. Prof. William Libbey, with a complete deep-sea dredging equipment, intends to work at the southern entrance of Smith sound, determining the course and direction of the southward currents, while the Porter party will be taken to the deer and walrus habitats on the Greenland side of the straits.

The *Diana* will take one year's supplies for the *Windward* party, which has not returned, and for her own party, so that in case of any unforeseen accident there will be no danger of lack of food. She will also carry mail and small packages from Norway for Sverdrup, in the *Fram*, who has not been heard from since his departure from Upernavik, July 30, 1898. The itinerary of the *Diana* is that planned by Mr Peary before leaving for the north last summer. The hope of meeting Peary or his representatives and of obtaining information concerning the winter experiences of the *Windward* and *Fram* parties will make the voyage of this summer one of more than popular scientific interest.

It is reported that to a deputation of the Royal Geographical Society which waited upon him a few days since, Right Hon. Arthur J. Balfour, First Lord of the Treasury, promised that the government would render substantial aid in furthering the work of an Antarctic expedition.

GEOGRAPHIC LITERATURE

A Thousand Days in the Arctic. By Frederick G. Jackson, Knight, etc. With Preface by Admiral Sir F. Leopold M'Clintock. 8mo, pp. i–xxiii + 1-940, with many illustrations, including five original maps. New York and London: Harper & Brothers. 1899. $6.

"This is an unvarnished tale of a thousand consecutive days spent in the Arctic, printed almost word for word as it was written . . . in our hut, or tent, when on sledging and boating journeys in Franz Josef Land. It is a simple, true account and statement of facts incident to our life and work there—plain facts, penned by a plain man." Such is the deprecatory note modestly prefixed by one of the foremost explorers of the decade to the published record of his work. Frederick G. Jackson, a Briton of characteristic physique and intelligence, is one of the legion lured by the ignis fatuus of the northern Pole; at the same time he is one of that division of the legion whose dreams are sane and whose strivings are sensible. On studying the conditions it seemed to him probable that Franz Josef Land (discovered and named by Weyprecht and Payer in 1873) might afford an overland route to the Pole; and, after much unsuccessful search for means, he at last effected a conjunction with Mr Alfred C. Harmsworth, who equipped an expedition for geographic work in the little-known land. Fortunately the patron was not more dazzled by the purely polar gleams than his explorer; it was his chief desire that Jackson and his companions should "add to our knowledge of the geography and the fauna and flora of Franz Josef Land and the area lying immediately north of it" (p. 774). Thus it was on a practical basis that the *Windward*, with the Jackson party on board, weighed anchor on July 12, 1894. A southerly point on Franz Josef Land was reached without great delay, and a landing was effected; but before the transfer of goods was completed the vessel was caught in the ice, and remained until the break-up of 1895, when she returned to England, leaving Jackson and his six companions on one of the most desolate spots ever touched by explorers. Nearly a year later the solitude was broken by that most marvelous accident of Arctic exploration, the meeting with Nansen and Johansen, who remained a month before embarking on the *Windward* on her return trip of 1896, while the British party remained another year, to be brought out by the same vessel in the summer of 1897. During the three years of their arctic sojourn Jackson and his experts were seldom idle. In the spring of 1895 a long sledge journey was made northward, resulting in the discovery that the supposed continuous land is but an archipelago. Later in the season a perilous, not to say foolhardy, sea trip was made in a half-seaworthy whale-boat, which resulted in a map of the southern coast and the location of the southwesternmost point of Franz Josef Land. Another sledge journey

northeastward, with further surveys, followed in the spring of 1896; but by far the most noteworthy sledge trip was that of the spring of 1897, when Jackson, with one companion (Albert B. Armitage), traversed the entire latitude of the more continuous portion of the archipelago, skirted its northern coast, approached its western headlands, and resurveyed the southern shore. The sledging trips were unique in Arctic exploration in that horses (Russian ponies) were used, up to the middle of the long trip of 1897, when the last of the original four succumbed on the great glacier covering the western portion of the westernmost island. The experience seems to establish the explorer's opinion that the use of properly selected horses is essential to the best results in polar work; certainly Jackson's longest trips were made possible only by this form of motive power, and it seems evident that if a fresh supply of suitable ponies had been brought in by the *Windward* in 1896, in lieu of the utterly useless reindeer, the work of the expedition might have been materially facilitated and enhanced in extent. True, a special strain of horse-flesh is required; docility to the degree of taking kindly to snow-shoes or assistance over ice-cracks and crevasses, hardiness enough to permit survival of snow-laden gales down to temperatures of —50°, and omnivorousness extending at least to dog biscuit and bread, and even to bear meat and bacon, are among the requisites; yet all these requisites are met by the Russian ponies, as Jackson's experience demonstrates. In the absence of the leader the naturalists at the home station, and at all other times except in the dead night of polar darkness, the whole party were occupied with studies and collections of the fauna and meager flora, the fossils and rocks, and the other natural features of the region; while the leader and others made maps, numberless photographs, and admirable meteorologic records. The mode of life was largely conventional—for Arctic regions; but the leader was a sportsman, possessed of strong convictions concerning modes of maintaining health, and kept the larder supplied by shooting bears, walruses, and (during the short summer) loons and other fowl nesting in the cliffs. The itinerary abounds in episodes, often approaching the tragic, and is of unsurpassed interest throughout. The monotony of the boat trip in 1895 was relieved by a three days' gale, by which the party in their shaky craft were blown out to sea, and so hardly and constantly beset that they were unable even to reach the food on board or to protect themselves from frost-bite, and were finally blown back to land by mere chance of wind and weather; the sledges crossed ice-cracks and soft sludge at sea and crevasses on the glaciers over frail snow-bridges, and dogs and ponies were again and again hauled out of jeopardy by their necks; in one case a sledge-load of food for a considerable trip was lost through rotten ice, and the return trip was a cold and hungry one. The interviews with fearless and hungry bears in the polar dark were often thrilling—as when one over-curious bear took twenty-three inches of rifle barrel and a hand above the wrist in his mouth before voting the contest a draw. Throughout, the explorer reveals himself the typical Englishman in character, in everyday custom, in mode of speech, and in habit of thought; he is monarch over his small domain, ruling his yeomanry with rod of iron, yet

always charging himself with their safety and comfort; he concentrates in his own person the energy and ambition and nearly all the individuality of the party, and inevitably dwarfs, in some measure, the abilities of the others; he alone, or nearly so, responds to the signal "Bear" sounded by dog or man, and leads the van on all occasions; and when ponies and dogs are broken down, it is he who takes the harness as leader of the team. Throughout it all he glories in his "tub;" even when but a gill of water can be painfully obtained by snow-melting, and when the blizzard howls far below zero, he creeps out on hummock or glacier to gloat over a sponge bath to the waist! And his philosophy is as characteristic as his language when, on summarizing the nasty boat trip, he says, "We have had an exceedingly near squeak for it, and it was very nearly ta-ta on many occasions" (p. 299). Though monarch of his domain, he is always Briton and mindful of Britain's Queen; and one of his mainsprings is the desire to extend Her Majesty's dominion even unto the futile shadow of the poles, and he rejoices in the opportunity to replace the imaginary portion of "Franz Josef Land" by a far-stretching "Queen Victoria sea." The geographic results of Jackson's work are notably valuable; he surveyed a large part of the little-known Franz Josef Land, showing it to be an inconsiderable archipelago rather than a great land mass extending to the Pole; he shows "Gillis Land" to be non-existent; and he gives an admirable record of the natural history and meteorology of a little-known portion of the globe. The "land" consists of a congeries of basaltic mesas rising a few hundred feet above sea, with the intervening valleys submerged; and nearly all the surface is mantled with perpetual snow, forming extensive névé-fields and glaciers whence bergs are constantly fed to the surrounding ocean. Apparently the region is one of peculiarly unstable climate; gales keep water and ice astir, so that the effect of summer is hastened despite the irregularity of the seasons, and this doubtless accounts for the incomplete glacial covering and hence for the considerable fauna, especially of bear and walrus and seal—which was, however, greatly reduced by Jackson's hunting. The bulk of the book is well illustrated itinerary; but 140 pages are devoted to appendices on the natural history of the region, and there is an important chapter on scurvy, containing the results not only of Arctic experience, but of experiments on monkeys in England. The publishers have done their work admirably; so that, on the whole, the book is one of the most instructive and attractive products of Arctic work thus far issued.

W J M.

Shoreline Topography. By F. P. Gulliver. (Proceedings of the American Academy of Arts and Sciences, Vol. xxxiv, No. 8, January, 1899.) Pp. 151–258.

As an able representative of the school of modern geographers fostered especially by the U. S. Geological Survey and Harvard University, Dr Gulliver is already favorably known; and this little monograph will add materially to his prestige and to the beneficial influence of his school. Throughout he employs and applies the genetic method, dealing with the shore features as products of recognized agency; dynamic agencies are indeed conceived to be conditioned by static factors of volume, structure,

hardness, etc., while the descriptive terms connote forms; yet the classification is in accord with latest phase of earth science, in that it is primarily genetic, only secondarily structural. Proceeding on this basis, the author naturally adopts as his thesis the postulate that "the forms of any coastal belt may be grouped in the appropriate stages of a cycle" (page 155)—*i. e.*, he passes easily from the dynamic to the sequential. The features discussed are adequately illustrated, chiefly by maps. W J M.

GEOGRAPHIC MISCELLANEA

THE exports of gold from the ports of South Africa at present average about $2,000,000 each week.

ON account of the withdrawal by the government of its annual subsidy the Jamaica Weather Service has been discontinued.

THE Budget Committee of the Reichstag has voted the first installment of $47,600 for the German Antarctic expedition of 1902.

IN the *Monthly Weather Review* for March is an article by the editor, Prof. Cleveland Abbe, outlining the history of meteorology in Russia.

A RECENT *Independent* (June 8) contains a history of "The Alaskan Boundary," by Marcus Baker, secretary of the U. S. Board on Geographic Names.

FOR the first time in the history of the Weather Bureau, forecasts for forty-eight hours in advance, for all states east of the Rocky mountains, were regularly issued from Washington each night during April, 1899.

REPORTS from Odessa and southern Russia represent the winter grain crop of that region as almost destroyed by drought. As the spring grain crop is likewise seriously threatened, it is feared that the crop may not exceed that of 1897.

REPORTS from Vancouver, B. C., announce the ascent for the first time of Mt Morrison, the highest mountain in Formosa, by Stoepel, the explorer of the Pic of Orizaba in Mexico. It is stated that Mt Morrison is inhabited by a wild tribe of cannibals, evidently of Malayan origin and distinct from any known race.

THE next meeting of the International Meteorological Committee will be held at St Petersburg August 25. Willis L. Moore, Chief of the Weather Bureau, is the representative of the United States. Among other members of the committee are E. Mascart, France; R. H. Scott, Great Britain; W. V. Bezold, Germany, and M. Rykatcheff, Russia.

The Nation states that Mr Charles F. Lummis is about to print in his *Land of Sunshine* (Los Angeles, Cal.) an accurate translation of the Viceroy Revilla Gigedo's report on California, the clearest and closest summary of Pacific Coast affairs and explorations from San Blas to Nutka, 1767–1793, that we possess. It has not been printed heretofore in English.

THE Union Pacific Company has invited three hundred prominent geologists to join in a free excursion of sixty days to study the recent fossil finds in the Wyoming wonderland. The professors of the various

large colleges throughout the country are especially invited, and transportation is to be furnished for at least one assistant free. The excursionists are expected to gather at Laramie, Wyo., on July 19.

Col. W. S. Brackett, of Peoria, Ill., a corresponding member of the National Geographic Society, has organized and equipped an expedition to determine the geologic and mineralogic features of the almost unknown region lying between Buffalo hump, in Idaho county, Idaho, and the Nez Perce pass, in the Bitter Root range. The party numbers twelve men, all experienced mountaineers, some of whom have been in that country since 1862.

The successful navigation of the vast and comparatively unknown interior of South America by the U. S. gunboat *Wilmington*, which ascended over 2,100 miles up the Amazon and its tributaries and reached Yquitos, in Peru, within 400 miles of the Pacific ocean, is another instance of the power of "the navy as a motor in geographical and commercial progress," so ably described by G. W. Littlehales in the *Bulletin of the American Geographical Society*, No. 2, 1899.

At the anniversary meeting of the Royal Geographical Society held in London, June 4, the Founders' medal was conferred on Captain Binger for his explorations in 1887-1889 in the region included in the bend of the Niger, while another Frenchman, M. Foureau, received the Patrons' medal for his extensive travels in the Sahara during the past twelve years. Ambassador Joseph H. Choate presented to Sir John Murray the medal awarded him by the American Geographical Society.

Dr C. Willard Hayes and Mr A. P. Davis, the respective authors of "Physiography of the Nicaragua Canal Route" and "Nicaragua and the Isthmian Routes," which appear in this number of The National Geographic Magazine, were detailed from the U. S. Geological Survey by the Secretary of the Interior for special duty on the Nicaragua Commission. They accompanied the Commission in its investigations on the isthmus, Dr Hayes as the geologist and Mr Davis as the hydrographer of the party.

Attention should be drawn to the valuable series of reports prepared by the Bureau of Statistics of the Treasury Department and given free to any one asking for them. Recent reports include *Commercial China in 1899*, with a map (13 by 14 inches) showing treaty ports, ports of foreign control, railways, telegraphs, waterways, etc.; *Submarine and Land Telegraph Systems of the World*, with map (14 by 21); *Colonial Systems of the World*, with map (13 by 21), and *Foreign Commerce of Cuba, Porto Rico, Hawaii, the Philippines, and Samoan Islands.*

The Duke of the Abruzzi, nephew of the King of Italy and an honorary member of the National Geographic Society, sailed from Christiania June 12, *en route* for the north polar regions. The outfit of the party has been divided into four sections, arranged in boxes of different colors, so that in an extremity the most important can be easily saved. The expedition consists of twenty-one persons, the second in command being Captain Cogni, who accompanied the Duke on his expedition to Mt St Elias in 1897, when that famous peak was ascended for the first time.

THE members of the new commission appointed by President McKinley to determine the best route for an interoceanic canal are as follows: Rear Admiral John G. Walker, Col. P. C. Hains, U. S. A., and Lewis M. Haupt, C. E., of the University of Pennsylvania (members of the commission which has just handed in its report); ex-Senator Samuel Pasco, of Florida; Alfred Noble, C. E., who was also on the Ludlow Canal Commission; George S. Morrison, C. E., of New York; Prof. Wm. H. Burr, of Columbia University; Lieut. Col. Oswald H. Ernst, U. S. A., and Prof. Emory R. Johnson, of Pennsylvania.

FROM a chart which the division of mines and mining of the U. S. Geological Survey will publish in a few weeks to show the total value of mineral productions in the United States for the years 1889–1898, it appears that the total value of mineral products in 1898 was nearly $700,000,000, as compared to $632,000,000 in 1897. This total represents simply the value of the material in its first marketable condition, and does not include coke, white lead, and other manufactured minerals. There was a general increase all along the line, especially in the production of bituminous coal, which increased from 147,600,000 short tons in 1897 to 166,500,000 short tons in 1898. The value of the gold production rose from $57,363,000 to $64,463,000, while the production of petroleum decreased 5,000,000 barrels in quantity, but increased $3,200,000 in value.

IN view of the recent developments in the industrial and transportation facilities of Russia, by which the products of her fields and forests may be increased and brought into closer competition with those of the United States, a recent report of O. P. Austin, Chief of the Bureau of Statistics of the Treasury Department, "*The Russian Empire and the Trans-Siberian Railway*," is timely. An examination of the map (21 by 15 inches) which accompanies the report shows that the trans-Siberian road is now completed for nearly two-thirds of the distance toward the Pacific, and that the construction of 600 miles of track eastward from Lake Baikal (the deepest lake in the world) will bring trans-Siberian trains to the navigable waters of the Shilka and Amoor rivers, which flow into the Pacific. Probably within two years a complete rail and water system across Russia and Siberia will be in operation.

ACCORDING to a recent publication of the Weather Bureau, *Lightning and the Electricity of the Air*, Bulletin No. 26, Part II. 312 persons on the average are killed annually by lightning in the United States. The author, Prof. A. J. Henry, believes that this number is below rather than above the true figure; in other words, that more comprehensive methods of reporting deaths by lightning would show a greater number than has thus far been recorded. The death-rate from lightning in the United States is apparently higher than in England, Norway and Sweden, France, and possibly the greater portion of the Russian Empire. It is about equal to that of the German Empire and probably a little less than that of Austria-Hungary. The danger of lightning stroke seems to be greatest in Wyoming, Colorado, Montana, and other portions of the Rocky Mountain country. In the South Atlantic states also it is above the average for the country at large. The regions of least danger are the Pacific coast and the Great Basin.

THE Johns Hopkins University has sent a medical expedition to Manila for the purpose of studying the characteristics of tropical diseases as they may be observed in the Philippine islands. Two of the professors in the Johns Hopkins Medical School, Dr Simon Flexner and Dr L. F. Barker, both of them highly trained pathologists of wide professional repute, volunteered for this service. They go well equipped with the best apparatus for pathological and clinical observations. They carry letters of introduction from officers of the government at Washington. Two medical students well advanced in their studies, Joseph M. Flint, of Chicago, and Frederick P. Gay, of Boston, are members of the party, and Mr J. W. Garrett, of Baltimore, is also a member. The expenses are defrayed by generous contributions from five Baltimore merchants. The party sailed from Vancouver for Manila, by way of Yokohama and Hongkong. Several days were passed in Japan, where Professor Aoyama, in Tokyo, gave them special opportunities for observing certain cases of disease in the hospitals of that city. Upon reaching Manila, Drs Flexner and Barker commenced work at once, their inquiries being facilitated by the coöperation of Colonel Woodhull, M. D., U. S. A. In Manila there are two large army hospitals, the first and second reserve, the civil hospital under Dr Bournes (who accompanied Prof. Dean C. Worcester in his travels through the islands), the prison hospital at Cavite, and a convalescent hospital at Corregidor.

IN "The Race for the North Pole," which appears in the June *Munsey*, Gen. A. W. Greely reviews the work of the three explorers, Peary and Wellman, Americans, and Sverdrup, Norwegian, who are trying to reach the Pole. Of the three explorers, Peary and Sverdrup have followed what is known as the American polar route by the channels leading from Baffin bay northward along the west coast of Greenland to the polar ocean. As to the probability of their success, General Greely states: "There are two phases of the question—first, whether the waterways to the west of Greenland are so ice-free as to justify the belief that either the *Windward* or the *Fram* can round the northwestern point of Greenland and enter St George's fiord; and, second, the possibility of the *Fram* circumnavigating Greenland, and that of either Peary or Sverdrup reaching the Pole by sledge journeys." Even should an open ice season permit either ship to reach St George's fiord, of which judging from past history there is little probability, it would never be able to leave the fiord. From St George's fiord the explorers could easily reach Cape Washington, the most northerly known land, 83° 24′ (gained by the Greely expedition), whence they would have a journey of 300 miles each way over the ice pack, or a distance three times greater than that covered by Nansen after leaving his ship. General Greely believes that Wellman, who has chosen the Franz Josef Land route, has the most difficult task before him. "The difficulties of ice travel are very much greater in the case of Wellman than of either Peary or Sverdrup. The distance over the frozen sea from the northernmost point of Franz Josef Land to the Pole and back again cannot be much less than 1,000 miles, and no reader who has studied the narrative of Markham or Nansen can believe that such a journey is within human power in a single season."

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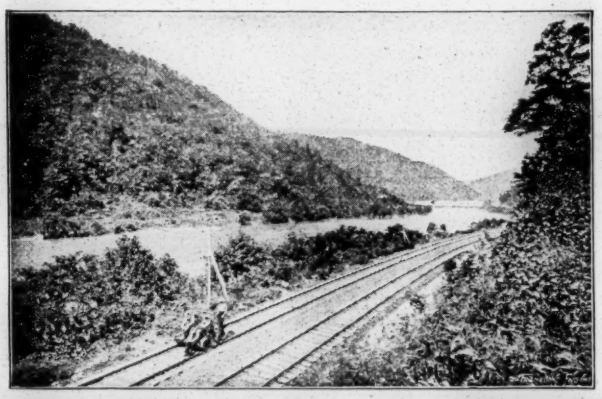

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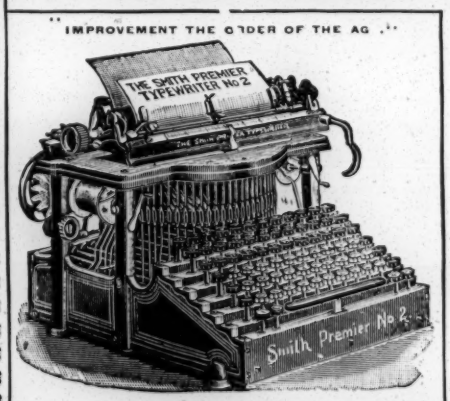

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